

*The
Anopheleine Mosquitoes
of India*

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A Monograph
OF THE
Anopheline Mosquitoes
of India

BY

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FROM THE PREFACE TO THE FIRST EDITION.

THIS book has been written at the request of some of our fellow-workers in India, so we need not apologise for its publication. Its scope is indicated in the title. We have attempted to treat the subject clearly, and to describe the different species in such a manner that any specimen collected will be easily identified. In our opinion this is the most important requirement of any book dealing with mosquitoes, and in connexion with it we venture to hope that our coloured plates will be found helpful. We are much indebted to our friend Dr. Turkhud, of Bombay, for having drawn them, under our direction, with so much care and skill.

PREFACE TO THE NEW EDITION.

ALL the copies of the first edition were sold within a few months, but we decided to postpone the issue of a new edition until we should be able to include in it the results of further study. We hope that the changes and additions now made will be held to justify our decision. We have kept in view that the purpose of the book is to aid in the correct determination of specimens, and the new matter on this subject includes a redescription of every species that was mentioned in the first edition. In common with many other medical men, we are greatly disappointed that no dipterologist has examined in detail Mr. Theobald's admirable pioneer work on classification and identification by scale structure, but, that being so, we consider that our endeavour in Chapter III needs no apology; it will serve its purpose if collectors find that it assists them in the task of identifying their specimens.

We are indebted to many workers for information and material, especially, as regards workers in India, to Captain Christophers, I.M.S.; N. Annandale, Esq., D.Sc.; Lieut.-Colonel Adie, I.M.S.; Major F. Smith, D.S.O., R.A.M.C., and Dr. C. A. Bentley; and, as regards workers in England, to F. V. Theobald, Esq., M.A.; Dr. J. W. W. Stephens and R. Newstead, Esq.


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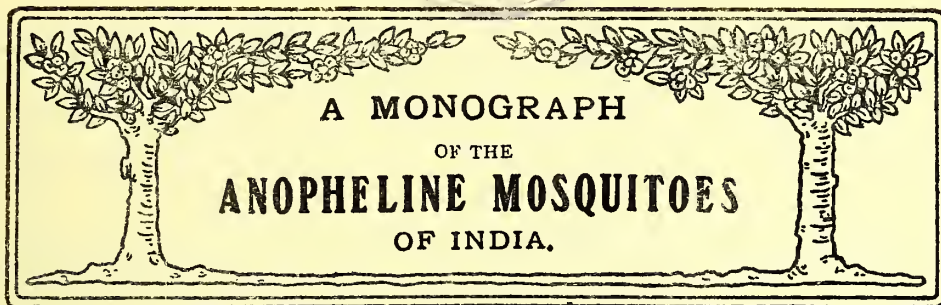
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PART I.





A MONOGRAPH
OF THE
ANOPHELINE MOSQUITOES
OF INDIA.

CHAPTER I.

A GENERAL ACCOUNT OF MOSQUITOES.



MOSQUITOES or gnats (CULICIDÆ) belong to the order of insects known as DIPTERA. As is well-known, a typical member of the class INSECTA has four wings, but it is characteristic of members of the order DIPTERA that the hinder pair of wings are so reduced in size as to form only small knobs called "balancers" or *halteres*, so that DIPTERA are often spoken of as "two-winged flies." Other important characters of members of this order are that the mouth parts are adapted for sucking—sometimes also for piercing—and that the insects undergo complete "metamorphosis"—a term which is explained by Claus in the following manner :—

"The more complete the agreement between the just-born young and the adult sexual animal so much the greater will be the duration of the embryonic development and the more complicated the developmental processes of the embryo. The post-embryonic development will, in this case, be confined to simple processes of growth. When, however, the embryo is born in an immature condition and at a relatively low state of organization, the post-embryonic development will be more complicated, and the young animal, in addition to its increase in size, will present various processes of transformation and change of form. In such cases the just-hatched young, as opposed to the adult animal, is called a *Larva* and develops gradually to the form of the adult sexual animal. The development of *larvæ*, however, is by no means direct and uniform, but is complicated by the necessity for special contrivances to enable them to procure food and to protect themselves; sometimes taking place in an entirely different medium, under different conditions of life. This kind of post-embryonic development is known as metamorphosis."

The phenomena of metamorphosis are well shown in the life history of insects. The different stages through which mosquitoes pass before they reach the adult state may, for example, be briefly described in the following way :—

The adult female mosquito lays its eggs on the surface of water. The eggs float on the water for some days (two to four), after which time they hatch into small wriggling animals called *larvæ*.

How to distinguish Mosquitoes from other Flies.

The larva is a free swimming worm-like animal, which eats greedily and grows rapidly, casting its skin several times in the process, till it reaches its full development. At this stage it suddenly changes its form; casting its skin, the worm-like larva assumes a comma shape, and becomes the *pupa* or *nympha*.

During the pupal stage the insect does not eat; it spends its time in struggling to the bottom of the water and rising to the surface to breathe; profound anatomical changes take place within the pupal skin, whereby the masticatory mouth parts of the larva are converted into the suctorial apparatus of the adult insect or *imago*. After a certain number of days the pupa-case ruptures, and the adult insect is liberated, furnished with wings and legs adapted for a life in the air.

The DIPTERA have been divided into two great groups, termed *Orthorrhapha* and *Cyclorrhapha*, according to the manner in which the pupa-case splits to permit the escape of the perfect insect. In the *Orthorrhapha*, which includes the *Culicidæ* (mosquitoes), the *Corethridæ*, the *Chironomidæ* (midges), the *Simuliidæ* (sand-flies), the *Cecidomyidæ* (gall-midges), the *Mycetophilidæ* (fungus-midges), the *Tipulidæ* (daddy-long-legs), the *Tabanidæ* (horse-flies), etc., the pupa-case splits longitudinally down the median dorsal line. In the *Cyclorrhapha*, which includes the *Syrphidæ* (hover-flies), the *Oestridæ* (bot-and warble flies), the *Muscidæ* (house flies, tsetse flies, blue and green bottle flies, flesh flies, etc.), the perfect insect escapes by the splitting off of a cap from the head end of the pupa.

The members of some of the above families are not infrequently mistaken for mosquitoes, especially the *Corethridæ*, the *Chironomidæ* or midges, the *Cecidomyidæ* or gall-midges, the *Tipulidæ*, the *Simuliidæ* and the *Psychodidæ* or owl-midges. Mosquitoes may, however, be easily distinguished from any other flies by the following characters.

- (1) They possess a long piercing and sucking proboscis.
- (2) The veins on their wings are covered with scales.
- (3) The arrangement of their wing-veins is characteristic and different from that of the members of any other family.

It is to be noted that one or other of these characters considered separately may not always enable us to say that the specimen is a mosquito; all of them must be present before we can make that statement. This will be apparent if we say a few words about the PSYCHODIDÆ, a family of diptera which has recently received

The chief groups of Mosquitoes.

much attention because it contains a "sandfly," *Phlebotomus papatasi*, which is said to be the carrier of a fever (*Pappatacifeber*) in India and other countries. The family contains two sub-families, the PHLEBOTOMINÆ and the PSYCHODINÆ, and in both of these the venation of the wing is not very unlike that of the CULICIDÆ. Moreover in the PSYCHODINÆ there are species having the wing veins densely clothed with true scales and in the PHLEBOTOMINÆ there are species having the proboscis formed for piercing and sucking. Thus from one of the diagnostic characters taken separately it would not be possible to distinguish between a mosquito and some of the PSYCHODIDÆ. It happens, however, that none of those flies possesses all the three characters that we have enumerated as being diagnostic of a mosquito.

At present the family CULICIDÆ contains not many less than 1,000 species. All of them can be classified in one or other of the following principal groups or sub-families :—

- | | | | |
|--|----|---|--------------|
| 1. Proboscis bent back in the form of a hook | .. | .. | MEGARHININÆ. |
| 2. Proboscis sharply bent forming an angle ("elbowed") | .. | .. | LIMATINÆ. |
| 3. Proboscis straight | { | i. Palpi roughly as long as the proboscis in both sexes | ANOPHELINÆ. |
| | | ii. Palpi very short in both sexes | .. AEDINÆ. |
| | | iii. Palpi short in the female, long in the male | .. CULICINÆ. |

To this grouping most dipterologists would add the sub-family *Corethrinæ* in which the proboscis is short and not formed for piercing or biting, but in excluding this sub-family we follow the present practice of Mr. Theobald and other specialists on mosquitoes. On the other hand, it is doubtful if any dipterologist would accept the sub-family LIMATINÆ, which contains at present only one species. In the attempt further to sub-divide the CULICIDÆ systematists have proposed a number of other sub-families, but their names are not of importance to us at present.

The sub-family ANOPHELINÆ, with which we are concerned in this book, contains more than 100 species, of which about one-third occur in India. There is no doubt that in regard to a number of so-called species different workers have given different names to the same insect, and in regard to others that "varieties" have been described as distinct species. This cause of confusion has been due chiefly to the fact that until interest in mosquitoes was aroused by the discovery that some of them are carriers of disease the descriptions of those insects as given by entomologists were very meagre and usually

Description of the Eggs.

included only such characters as were observed (often inaccurately) with the naked eye or a hand-lens. During recent years the descriptions have been much more accurate and complete so that in time the confusion will disappear.

In the following more detailed summary of the different stages in the metamorphosis of mosquitoes we shall describe the characters by which anopheline mosquitoes may be recognised.

THE EGG OR OVUM.

The eggs of most mosquitoes, before being deposited by the female, are collected together, in the angle made by the crossing of the insect's hind legs, so as to form an elongated boat-shaped mass consisting of several hundred eggs joined to one another by their edges. When this egg-boat or egg-raft has been constructed the insect allows it to drop into the water, where it floats as a small oblong boat-shaped body somewhat raised at each extremity (Pl. I, Figs. 4, 5, 6). The shape and character of these egg-rafts vary in different genera. In the genus *Culex* (sub-family CULICINÆ) they are broad and more or less oval in shape; in the genus *Tæniorhynchus* (sub-family CULICINÆ) they are said to be very elongated and to resemble a racing skiff in shape (Stephens and Christophers).

The eggs of all anopheline mosquitoes, on the other hand, as well as those of some culicine mosquitoes (*e.g.*, those of the genera *Stegomyia*, *Panoplitæ*, *Psorophora* and *Janthinsoma* of the sub-family CULICINÆ) are not collected together into a mass of definite shape before deposition; the individual eggs do not stick together, so that when laid on a solid object they form only a piled up mass, and when laid on water they quickly separate from one another and float as isolated elements (Pl. I, Fig. 1). Owing to physical causes, the eggs, when deposited on water, may arrange themselves in fairly definite star-shaped patterns or in rows, but more frequently they are scattered irregularly over the surface of the water. The individual eggs which compose an egg-raft of culicine mosquitoes, are oblong in shape, and broader and more rounded at one end than at the other

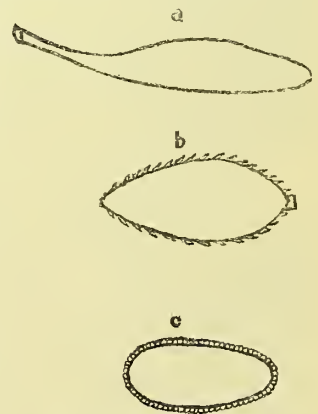


Fig. 1 (after Daniels).

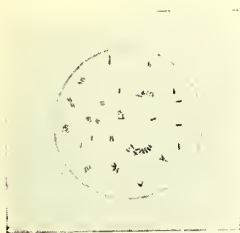


FIG. 1.



FIG. 2.



FIG. 3.



FIG. 4.

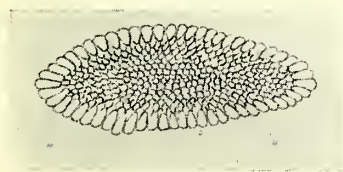


FIG. 5.



FIG. 6.



FIG. 7.



FIG. 8.

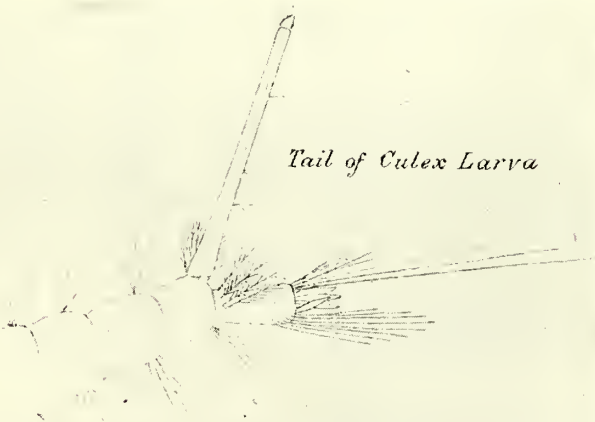


FIG. 9.

PLATE I. Fig. 1.—“*Anopheles*” eggs. Natural size; Fig. 2.—Egg of *rossii*, magnified, showing the upper surface, the lateral floats, and the beaded rim; Fig. 3.—Lateral view of the same; Fig. 4.—Raft-like masses of “*Culex*” eggs, natural size; Fig. 5.—A raft mass of “*Culex*” eggs, magnified; seen from above; Fig. 6.—Lateral view of the same; Fig. 7.—Four “*Culex*” eggs, greatly magnified; Fig. 8.—Posterior extremity of “*Anopheles*” larva showing sessile stigmatic apparatus and “palmate hairs”; Fig. 9.—Posterior extremity of “*Culex*” larva.



Anopheline Eggs.

(Pl. I, Fig. 7). When joined together to form the raft they lie vertically with the narrow end out of the water and the broad end—from which the larva escapes—submerged. The eggs of mosquitoes of the genus *Mansonia* (Fig. 1a) have one end terminating in a fine point (Daniels), and those of the genera *Stegomyia* and *Psorophora* (Fig. 1, b & c) are peculiar in that, besides being more or less oval in shape, they possess a rim of cells somewhat resembling the rim or frill present in anopheline eggs.

A typical anopheline egg (Pl. I, Figs. 2, 3) is a boat-shaped body about 0.7 to 1.0 mm. in length. The upper surface or “deck” is flattened, but slightly convex, and is surrounded by a narrow beaded rim or frill. One end of the egg is slightly deeper and fuller than the other, and it is toward this end that the head of the embryo is directed. Along the centre of each side of the egg is attached an oval ribbed air-containing “float” (see also Fig. 8). These floats are very characteristic structures and are not present in the eggs of any other kind of mosquito as yet described. Their shape and position differ in the eggs of different species of anophelines, as does also the width and extent of the beaded rim or frill already described, and Stephens and Christophers have shown that it is possible to distinguish the eggs of some species by the position and characters of these two structures. These distinctions between the eggs of the various species will be described later.

THE LARVA.

The larvæ of all mosquitoes are made up of: (1) the head, (2) the thorax, and (3) the abdomen. The shape and characteristics of these three regions differ in the various sub-families, genera and even species of mosquitoes, but the characters of the abdomen afford the readiest means of distinguishing between the main groups and must therefore be described first. The abdomen is divided into nine segments. The first seven segments closely resemble one another and need not be specially described. The eighth segment carries the external openings (*stigmata*) of the respiratory tubes or *tracheæ*, by means of which oxygen is supplied to the tissues of the larva. In all anopheline larvæ the two large tracheæ open directly on the upper surface of the eighth segment by two stigmata which are surrounded and supported by a complex apparatus (Pl. I, Fig. 8). In the larvæ of other kinds of mosquitoes

The Larva.

the respiratory tubes do not open directly at the surface of the segment, but are prolonged onwards into a projection from the segment known as the siphon tube (Pl. I, Fig. 9). The absence of a siphon tube in anopheline larvæ renders their recognition from among the larvæ of all other kinds of mosquitoes an easy matter. For the identification of the different kinds of culicine larvæ the length and character of the siphon tube are of great value. Thus in larvæ of the genus *Stegomyia* the siphon tube is very short and thick, and in those of the genus *Culex* it is long and thin. Stephens and Christophers employ the term "siphonic index" for the figure obtained by dividing the length of the siphon tube by its greatest breadth, and state that for the different species in any genus this figure is very constant. In *Stegomyia* larvæ, for example, the siphonic index is about 2, *i.e.*, the length of the tube is about double its greatest breadth, in *Culex* larvæ it is about 4, and in *Tæniorhynchus* larvæ it may be as much as 13.

The ninth abdominal segment is cylindrical in shape and carries the opening of the anus, around which are symmetrically arranged the four anal papillæ. On the dorso-lateral surface of certain of the abdominal segments of anopheline larvæ characteristic structures called "palmate hairs" are present (*see* Pl. III). Each of these hairs has a short stalk, to the apex of which are jointed a number of leaflets which, when spread out, are arranged somewhat like the ribs of an umbrella which has been turned slightly inside out, or perhaps more nearly like the leaf of a cocoanut palm. Two of these palmate hairs are present on each segment which is provided with them, and it is chiefly by their means that the larva maintains its position close under the surface of the water. They are not present on the larvæ of any other kinds of mosquito than those of the sub-family ANOPHELINÆ.

On account of their presence and on account of the absence of a siphon tube anopheline larvæ float in the water immediately beneath and parallel with the surface film (Pl. II, Fig. 2).

On account of the presence of a siphon tube and the absence of palmate hairs the larvæ of other kinds of mosquitoes float considerably below and at an angle with the surface film (Pl. II, Fig. 1).

These are the essential differences by which anopheline larvæ may be distinguished from the larvæ of other kinds of mosquitoes. The head of an anopheline larva (Pl. III) is more or less rounded in

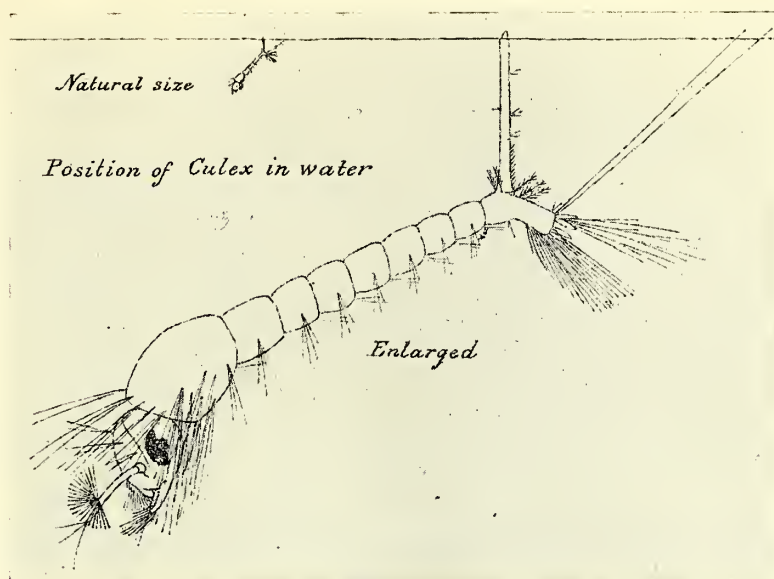


FIG. 1.

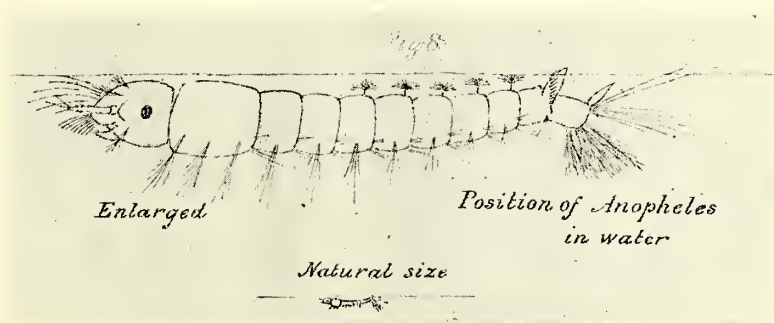


FIG. 2.

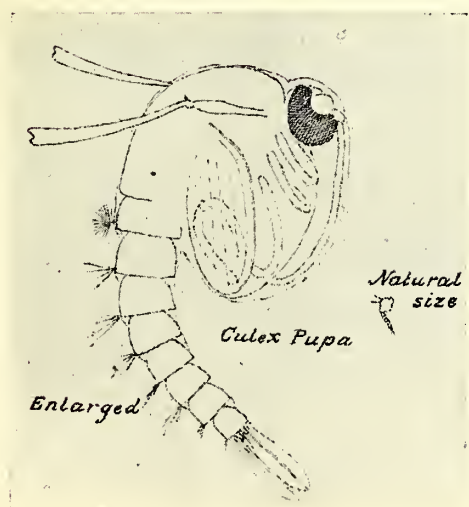


FIG. 3.

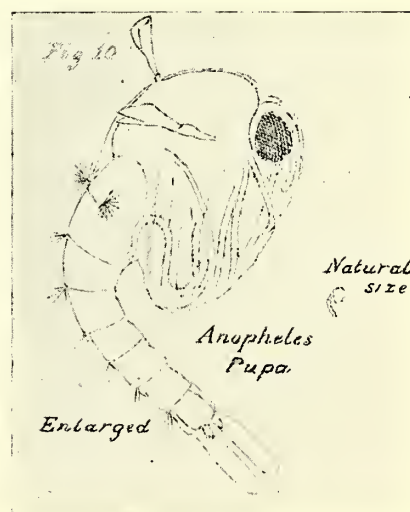


FIG. 4.

PLATE II. Fig. 1.—Larva of “*Culex*,” showing the position at the surface of the water; Fig. 2.—Larva of “*Anopheles*,” showing the same; Fig. 3.—Pupa of “*Culex*”; Fig. 4.—Pupa of “*Anopheles*.”



The Larva.

shape and is covered by a clearly defined chitinous case. The eyes are situated laterally, and in front of each eye is an eminence which carries the antenna. A broad band of pigment runs across the head between the two eminences from which the antennæ arise, and this carries six branched hairs which project forward over the head (*see* Pl. III). Arising from the corner of each eminence, and situated just outside the most external of the six hairs just mentioned, is a characteristic hair that we have called the "basal hair." It is seen projecting forwards just outside and parallel to the antenna in Plate VII, fig. 2, A, and in the figures of the larvæ of *karwari*, *culiciformis*, etc. It differs in character in different species and is of value in the identification of larvæ. The anterior median area of the head is called the clypeus, and it carries on each side a large bunch of hairs called the whorl organs or "feeding brushes." Lying directly over each whorl organ is a hair which may be called the external frontal hair or external clypeal hair, and between the whorl organs of each side is a pair of hairs close together which may be called the median frontal or clypeal hairs. These four frontal or clypeal hairs project beyond the head and may be simple or branched (Pl. III, C). They are of great service in the identification of the larvæ of different species and will be more particularly referred to later. In some larvæ, *e.g.*, *turkhudi* and *jeyporiensis*, a third hair called the "posterior hair," arises from the clypeus just behind and between the two frontal hairs of each side. This hair is also of some service in identification. It is shown in Plate VII, fig. 2, and in Plate VIII, fig. 2. The sides of the mouth are formed by the mandibles, and its floor by the maxillæ. Each mandible carries a number of stout teeth, which, working in conjunction with those of the mandible of the opposite side, serve to crush the food.

In full grown larvæ the thorax is broader than the head or than any of the abdominal segments (Pl. III). It carries a number of branched hairs, and in some species, a pair of well-developed palmate hairs similar to those present on the abdominal segments can be easily seen.

A few words may be added regarding the movements of larvæ in water and their method of feeding. Anopheline larvæ change their position at the surface of the water by a series of very characteristic jerking, darting movements in a backward direction. When actually occupied in feeding they lie stationary beneath the surface

The Larva.

film, only their mouth parts moving. The larvæ of other kinds of mosquitoes do not dart along at the surface in a backward direction as anopheline larvæ do, but when engaged in feeding they are propelled slowly forwards by the action of their mouth parts. Both kinds of larvæ, when disturbed, usually wriggle rapidly to the bottom of the pool, where they lie motionless with their bodies extended. Anophe-line larvæ sometimes do not wriggle to the bottom, but simply extend their bodies and allow themselves to sink by virtue of their weight. When rising to the surface the movements of these larvæ are much more jerky than those of other kinds.

Anopheline larvæ feed just beneath the surface film, and, whilst feeding, the head is rotated so that its ventral surface lies uppermost,

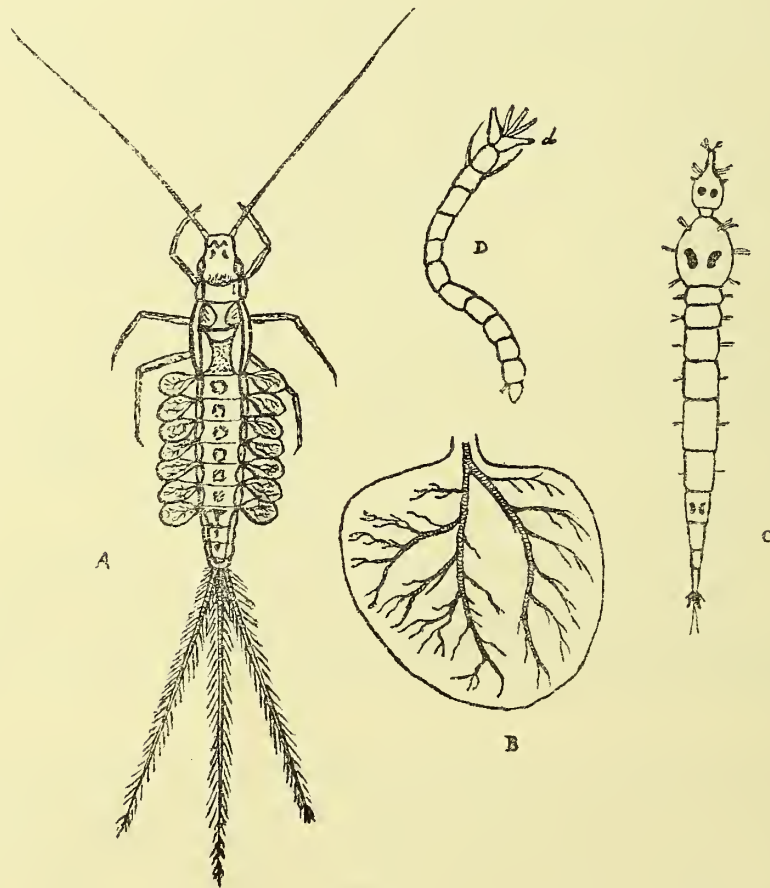
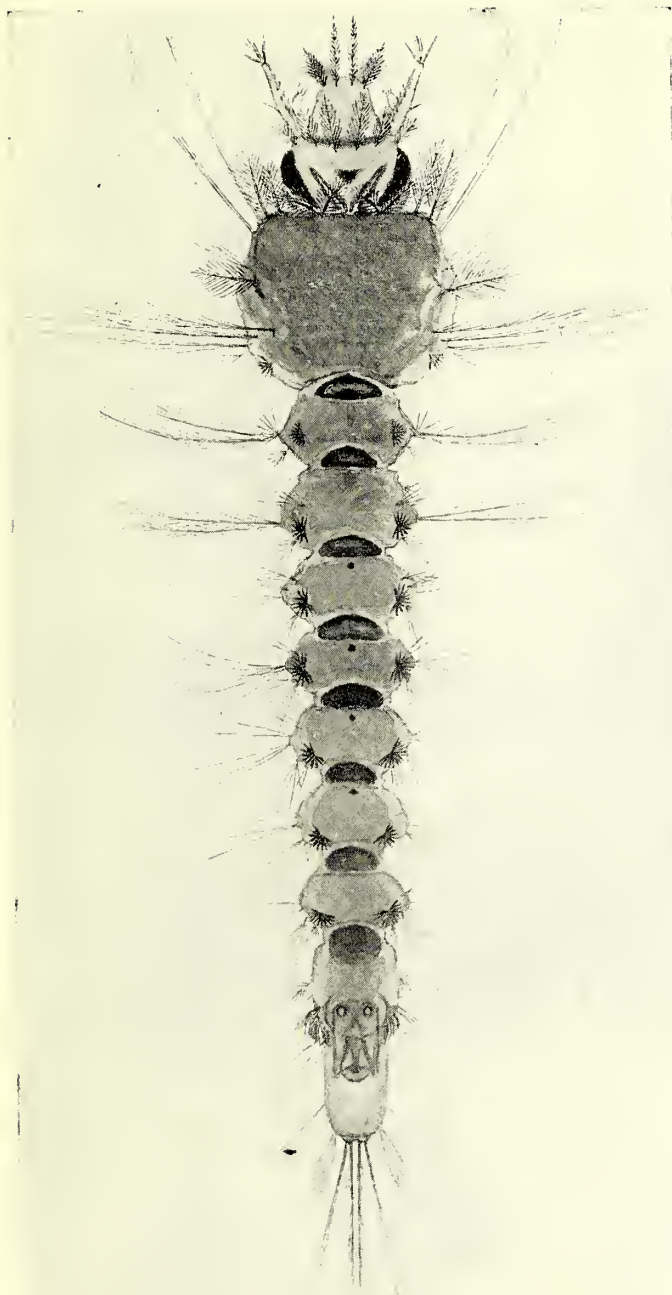


Fig. 2.

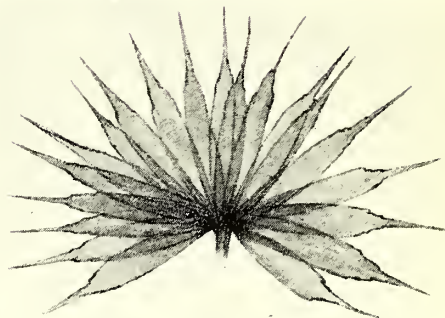
To face page 8.

PLATE III.

A



B



C



PLATE III. The larva of an anopheline (*maculipalpis*); A.—General view of the full-grown larva; B.—One of the palmate hairs magnified; C.—The frontal hairs (Median and External) of the right side, magnified.



The Larvæ of other Flies.

though the body of the larva remains in its original position. This rotation of the head is very characteristic and is peculiar to the larvæ of this kind of mosquito. Culicine larvæ often feed at the bottom of a pool, moving along in their natural position and picking up stray bits of food of all kinds.

The aquatic larvæ of other flies than mosquitoes may sometimes be mistaken for mosquito larvæ. There are, for example, the larvæ of the flies called *Chironomus*, *Ephemera* and *Dixa*. *Chironomus* larvæ are often found in large numbers when the mud at the bottom of a small pool is stirred up. They are bright red worm-like creatures and are commonly known as "blood worms." Although their tracheæ open externally in a pair of "respiratory tubes" (fig. 2 D, d) in appearance they bear no resemblance to mosquito larvæ. The larvæ of the EPHEMERIDÆ or May flies, so well known to fishermen in England, differ essentially from those of mosquitoes in that their air-tubes do not open externally, so that they obtain the oxygen they require from the water by means of gills, the presence of which makes them very easily recognisable (Fig. 2, A & B). It should also be noted that in *Corethra* larvæ (Fig. 2, C) there is no direct communication of the air-tubes with the external air. The larvæ of this kind of fly are very transparent, and are called for that reason "phantom larvæ." The head is much smaller than that of any mosquito larva. There are four distinct respiratory sacs which do not, however, contain air. The larvæ have no spiracles and, except when nearly full grown, no air-tubes. The four air-sacs act as floats only, and at no period of larval life is there any direct communication with the external air. It will be seen therefore that these larvæ are very different from mosquito larvæ, and this is one of the reasons for the separation of the CORETHRIDÆ as a distinct family.

Dixa larvæ bear a superficial resemblance to anopheline larvæ and float just beneath the surface film as the latter do. The fact that all the segments of *Dixa* larvæ are almost equal in size, the fact that they have no palmate hairs, and that they possess four prolegs, by using which they creep up the side of the vessel in which they are placed, should prevent any difficulty being experienced in distinguishing these larvæ from those of the ANOPHELINÆ. No *Dixa* has yet been found in the plains of India.

The Pupa and the Adult Insect.

THE PUPA OR NYMPH.

The pupæ of mosquitoes are active creatures, rising and falling in the water at will. Unlike the larvæ, they can sink in the water only by violent exertions with their tails. As soon as these movements of the tail cease, the buoyant pupa floats up to the surface again. Like the larvæ, they breathe air through protruding spiracles; but these air tubes, instead of being at the tail end, as in the larva, are placed on the dorsum of the thorax, as two trumpet-shaped structures projecting like horns. (Pl. II, figs. 3, 4).

The length and shape of these spiracles enable anopheline pupæ to be recognised.

Anopheline pupæ have short, stumpy, funnel-shaped spiracles (Pl. II, fig. 4), while those of culicine mosquitoes are longer, more slender, and trumpet-shaped (Pl. II, fig. 3).

THE ADULT MOSQUITO OR IMAGO.

The adult mosquito is divided into (1) the head, (2) the thorax, (3) the abdomen. To the head are attached sensory and suctorial appendages; while to the thorax are attached the legs and wings. (See Descriptive Diagram of a female anopheline. Coloured plate No. I.)

The head is rounded and attached to the thorax by a narrow neck. The portion of the head near the neck is called the nape. Above and in front of the nape is the occiput. In front of the occiput is the vertex, and occupying the greater part of the antero-lateral portion of the head, are the two compound eyes. Immediately anterior to the eyes, on either side, arise the antennæ, which are long, jointed structures provided with hairs. In the male the antennæ are very prominent hairy organs (Pl. IV, figs. 1, 3); in the female they are less conspicuous and almost devoid of hairs. (Pl. IV, figs. 2, 4).

In front of the antennæ will be noted a firm median chitinous prolongation, the "clypeus." Beneath the clypeus arise the mouth parts, which consist of seven pieces collectively termed the "proboscis."

The mouth parts are:—

- (1) the upper lip, made up of labrum and epipharynx;
- (2) & (3) two mandibles;
- (4) & (5) two maxillæ;
- (6) the hypopharynx or tongue,
- (7) the lower lip or labium.



FIG. 1.



FIG. 2.



FIG. 3.



FIG. 4.

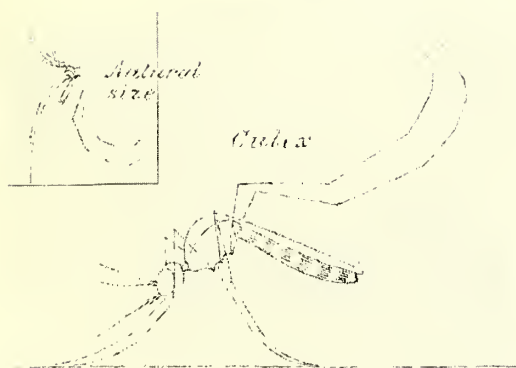


FIG. 5.

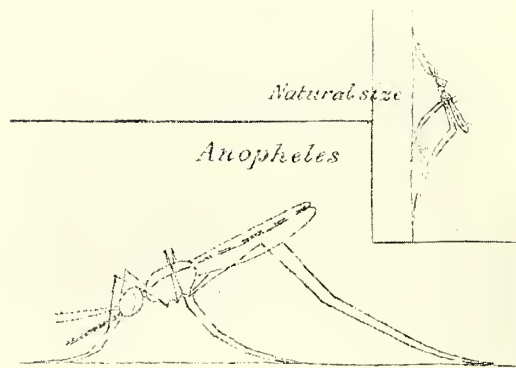


FIG. 6.

PLATE IV. Fig. 1.—Head of a male "*Culex*"; Fig. 2.—Head of a female "*Culex*"; Fig. 3.—Head of a male "*Anopheles*"; Fig. 4.—Head of a female "*Anopheles*"; Fig. 5.—A female "*Culex*," showing the position usually assumed when at rest on a surface; Fig. 6.—A female "*Anopheles*," showing the position usually assumed when at rest on a surface.



The Adult Insect.

The labium is a grooved structure, within which the other six mouth parts are enclosed.

In the ANOPHELINÆ, the AEDINÆ, and the CULICINÆ the proboscis is straight, but in the MEGARHININÆ its end is bent backwards like a hook.

Attached to the maxillæ are two maxillary palpi. The palpi of anopheline mosquitoes are very prominent organs, as long as the proboscis in both sexes, and clubbed at their extremity in the males. (Pl. IV, figs. 3, 4). Each palp has four segments.

In the sub-family AEDINÆ the palpi are very short in both sexes so that in order to see them distinctly one has to use a lens. In the sub-family CULICINÆ they are very short in the female but long in the male. (Pl. IV, figs. 1, 2). These very distinctive characters together with the character of the proboscis, already mentioned, have enabled the CULICIDÆ to be classified in the main sub-families enumerated on a previous page.

The thorax is mainly composed of the middle division or mesothorax; it is large and convex. Behind the main part of the thorax a prominent ridge runs between the bases of the wings; this ridge is called the "scutellum." In the ANOPHELINÆ the scutellum is never trilobed as it is in all other kinds of mosquitoes. Posterior to the scutellum, a horse shoe-shaped area is seen; this is the "metanotum." Projecting laterally, behind the metanotum, the club-shaped halteres will be noted.

We must refer in a little more detail to a pair of important structures situated one on each side of the anterior aspect of the prothorax. Each is called a "prothoracic lobe" or *patagium* and is an almond-shaped body partly separated from the prothorax by a deep groove. In order to see one of these bodies from the dorsal aspect the mosquito must be turned slightly on its side and examined with a low power of the microscope. For our present purpose the importance of the patagia lies in the fact that their characters have been used as a chief distinction between the genera of some anophelines. It has been said, for example, that in anophelines of the genus *Stethomyia* each prothoracic lobe or patagium carries a small nipple-shaped globe (that is that the "prothoracic lobe is mammilated") but that in anophelines of the genus *Anopheles* this little knob is absent. We may point out, however, that the knob is merely the termination of a strong ridge or

The Adult Insect.

bar which runs downwards and inwards from the prothoracic lobe to the base of the anterior leg and that being an essential structure for the attachment of muscles it is doubtless present in all anophelines. The ridge has been described and figured by Nuttall and Shipley in their admirable account of *Anopheles maculipennis* and we have detected it without difficulty in fresh specimens of all the Indian species we have examined. In dried specimens the ridge and its knob shrink so much that they cannot always be detected. Each prothoracic lobe carries hairs and in some species a prominent tuft of scales projecting from the anterior border forms a useful character in identification.

The abdomen is more slender than the thorax, and is usually described as consisting of eight segments, each being composed of a dorsal plate or tergum, and a ventral plate or sternum, joined together by a soft membrane. The anus opens on the ventral surface of the last segment, and to this segment are attached the genitalia.

Attached to the under-surface of the thorax are the six legs, three on each side (anterior, middle, and posterior pairs of legs). Each leg consists of the following parts:—Two small segments, the coxa and trochanter (these cannot be seen from the dorsal aspect), two longer segments, the femur and tibia, and, lastly, five tarsal segments. The first tarsal segment is sometimes called the metatarsus.* Between the tarsal segments are the tarsal joints. Entomologists have been accustomed to call the tarsal segments “joints” but at Captain Liston’s suggestion Mr. Theobald has adopted the terminology described here.

The wings of mosquitoes are mapped out with veins which are covered with scales. These veins have a very definite arrangement, and a knowledge of the names applied to them is essential in distinguishing the different species.†

The external or anterior border of the wing is called the costa. Running parallel with the costa is the first longitudinal vein. Immediately behind and arising about the junction of the inner with the middle third of this vein is the second longitudinal vein. After com-

* For example in Vols. I to III of Mr. Theobald’s monograph. In Vols. IV and V, he has followed the nomenclature described in this book.

† The reader will be greatly helped by following these veins as well as other structures noted, on the descriptive diagram of a female anopheline (coloured plate No. I).

The Adult Insect.

pleting about half of its course this vein divides into two branches, the anterior and posterior branches of the second longitudinal vein.

Behind the second longitudinal vein and arising about the middle of the wing is the third longitudinal vein.

The fourth longitudinal vein arises at the base of the wing, and in the last quarter of its course divides into two branches, anterior and posterior.

The fifth longitudinal vein also arises from the base of the wing; at about the middle of its course it divides into two branches, anterior and posterior.

The sixth longitudinal vein is unbranched, arises from the base of the wing, and terminates about the middle of the posterior border of the wing.

Joining these longitudinal veins with one another are certain transverse veins.

The most important of these transverse veins is the "the subcostal" which, arising near the origin of the first longitudinal vein, passes obliquely forwards and outwards to meet the costa about the beginning of the outer third of its course. This is the only transverse vein that is covered with scales.

Joining the first long vein to the origin of the second long vein is a very short transverse vein, "the marginal transverse vein."

Joining the origin of the third long vein to the second long vein is "the super-numerary cross vein." The vein joining the third long vein to the fourth long vein is the "mid cross vein."

The vein joining the fourth long vein to the anterior branch of the fifth long vein is called "the posterior cross vein."

The first, third, and sixth longitudinal veins are unbranched. The second, fourth, and fifth long veins divide in their course into two branches. The areas enclosed between these branches have received names. The area enclosed between the branches of the second long vein is called "the first submarginal cell;" that between the branches of the fourth long vein, "the second posterior cell," and that between the branches of the fifth long vein, "the anal cell." The relative length of the first submarginal and the second posterior cell is a character of specific importance. Names have been applied to the other areas of the wing enclosed between the various veins, but for

Scales and hairs.

our present purpose they need not be mentioned. The posterior margin of the wing is always fringed with long scales, "the wing fringe."

No account of the characters of mosquitoes would be complete without some remarks on scale structure, the importance of which has been very ably demonstrated by Mr. Theobald.*

In the first edition of this book we recognised the great importance of a study of scale structure and gave all the facts at that time known regarding the subject in its relation to the classification of the ANOPHELINÆ, but we stated that in our opinion it was unnecessary to adopt the method for the arrangement and identification of the Indian species. During the years that have since elapsed the number of anophelines described from different parts of the world and from India has increased considerably and further work has convinced us not only that it is advantageous to subdivide the ANOPHELINÆ into groups of genera, but that Mr. Theobald's method is the most satisfactory one at present known for that purpose. We therefore intend to adopt it in this edition and by making slight changes in Mr. Theobald's definitions of some genera and correcting certain errors that were inevitable in the noteworthy pioneer work undertaken by him, we hope to make the subject easily understood and to place the classification of the chief Indian anophelines on a sound basis. As we shall devote a special chapter to the subject it is necessary here to make only a few general remarks. As regards the character of the scales and hairs on anophelines we divide them into (1) *True scales*, (2) *False scales*, (3) *Hairs*. By *True scales* we understand those in which the striæ are clearly marked and pass as distinct supporting rods from the base of the scale to the apex. If these scales are examined under a high power of the microscope the number of striæ can always be counted and it can be seen that the striæ often project beyond the level of the end of the scale. The clearly marked dark striæ separated from one another by clear transparent spaces represent for us the distinctive character of these scales. By a *False scale*, we understand a structure that may be of the same length and shape as a true scale, but in which when examined under a high power of the microscope definite dark striæ cannot be detected. In some of these false scales there may be an appearance of linear marking, but

* "A monograph of the Culicidæ of the world" by Fred. V. Theobald, M.A., F.E.S., British Museum (Natural History), Vols. I & II, 1901; Vol. III, 1903; Vol. IV, 1907; Vol. V, 1910.

The shape of scales.

striae passing from the base to the apex and which can be counted are not present. Both true and false scales are broader in the middle of their length than at their base, that is, they expand from the point of insertion. On the contrary, a *hair*, in our view, tapers evenly from the base to the apex. Moreover, a hair is easily distinguished from either a true or false scale by the fact that the middle part of its whole length is clear and transparent, presenting no linear marks or striae. These points are illustrated diagrammatically in several of the plates on subsequent pages. We are aware, of course, that our definitions are artificial and open to criticism, but we desire to avoid ambiguous descriptions such as "hair-like scales" and "scale-like hairs" and to this end our artificial distinctions are of advantage.

The shape of the various scales present on mosquitoes is considered to be of generic and specific importance by entomologists. Unfortunately, however, the descriptions that have been given of the shapes of scales are very indefinite and do not convey the same meaning to different people. We consider, therefore, that it would be very advantageous if all observers would agree to adopt for the shape of scales the nomenclature that botanists adopt for the shape of leaves. Botanists divide leaves into three groups (*a*) those that are broadest in the middle—such leaves may be orbicular, rotundate, broadly elliptical, oblong elliptical, oblong, linear, or acicular; (*b*) those that are broadest at the base—such may be deltoid, ovate, lanceolate, cordiform or sagittate; (*c*) those that are broadest at the apex—such may be obcordiform, obovate, oblanceolate, obsagittate or spatulate. All these terms have a definite meaning and significance and convey the same meaning to everyone who consults the figures of them given in any elementary book on botany. The only one of them that is commonly used by entomologists is "lanceolate," but even that term is quite incorrectly used. Thus the shapes of the wing scales in the genera *Anopheles*, *Myzomyia*, *Stethomyia*, *Pyretophorus* and *Myzorhynchus* are defined as being "lanceolate," "slightly lanceolate," "small lanceolate," "large lanceolate" or "dense lanceolate." As a matter of fact, none of those wing scales is lanceolate at all, because they are all broadest in the middle or towards the apex, and a lanceolate scale is one that is broadest at the base. Using the botanical terms in their correct sense we should, as a rule, describe the wing scales in the genera *Anopheles* and *Myzomyia* as being narrowly oblong-

List of Indian Anophelines.

elliptical, but in one or two species of the genus *Myzomyia* they are almost linear. In the genera *Cellia* and *Myzorhynchus* they are obovate as a rule, but some of the scales are broadly oblong-elliptical. Again the scales of the head usually referred to as "upright forked scales" would be more properly termed obsagittate scales. Oblanceolate scales are the commonest kind on the abdomen of some anophelines and orbicular and rotundate scales are found on the abdomen in the genus *Cellia*. The names may sound clumsy to those unfamiliar with them, but they are certainly preferable to such meaningless terms as "flat scales," "large and inflated scales," "flat and much expanded scales," etc. In this general account the subject of scales and hairs need not be further mentioned to, but we shall return to it in the chapter dealing with classification.

It remains in this chapter to enumerate the different anophelines that are at present known to occur in India, and for completeness we shall prefix to each specific name the generic name which we regard as correct. When a species is marked with one asterisk it means that we have not examined its scale structure and that it is placed in the genus only provisionally. When a species is marked with two asterisks it means that we have not seen it.

THE ANOPHELINES OF INDIA.

A. DESCRIBED OR NAMED SPECIES.

- Neostethopheles aitkeni*, James.
- Neostethopheles culiciformis*, James and Liston.
- Anopheles bariannenses*, James.
- Anopheles immaculatus*, Theobald.*
- Anopheles turkhudi*, Liston.
- Patagiamyia gigas*, Giles.
- Patagiamyia simlensis*, James.
- Patagiamyia lindesayi*, Giles.
- Myzomyia culicifacies*, Giles.
- Myzomyia listoni*, Liston (= *christophersi*, Theobald).
- Myzomyia leptomerus*, Theobald** (probably = *culicifacies*).
- Neomyzomyia elegans*, James.*
- Pyrethophorus jeyporiensis*, James.
- Pyrethophorus nigrifasciatus*, Theobald ** (perhaps is *Anopheles turkhudi*).
- Pyrethophorus nursei*, Theobald ** (perhaps is a variety of *turkhudi*).
- Nyssorhynchus maculatus*, Theobald.
- Nyssorhynchus pseudowillmori*, Theobald** (probably = *maculatus*).
- Nyssorhynchus fuliginosus*, Giles.
- Nyssorhynchus jamesi*, Theobald.
- Nyssorhynchus theobaldi*, Giles.
- Nyssorhynchus maculipalpis*, James and Liston (not Giles).

List of Indian Anophelines.

Nyssorhynchus indiensis, Theobald** (probably = *maculipalpis*).
Nyssorhynchus karwari, James.
Nyssomyzomyia rossi, Giles.
Nyssomyzomyia punctulata, James & Liston.
Nyssomyzomyia ludlowi, Theobald.
Neocellia indica, Theobald.
Neocellia stephensi, Liston.
Neocellia intermedia, Rothwell (probably = *stephensi*).
Neocellia willmori, James.
Neocellia dudgeoni, Theobald** (probably = *willmori*).
Cellia pulcherrima, Theobald.
Myzorhynchus barbirostris, Van der Wulp.
Myzorhynchus sinensis, Wiedmann.
Myzorhynchus vanus, Walker (= *senensis*).
Myzorhynchus nigerrimus, James and Liston (probably = *sinensis*).
Myzorhynchus minutus, Theobald** (= *nigerrimus*, James and Liston = *sinensis*, Wiedmann, = *vanus*, Walker).
Myzorhynchus nigerrimus, Giles** (probably a wrongly described specimen or a variety of *nigerrimus*, James and Liston).
Christophersia halli, James.
Aldrichia error, Theobald.**

B. DESCRIBED VARIETIES.

Potagamia lindesayi, variety *maculata*, Theobald.**
Myzomyia culicifacies, variety *punjabensis*, James.
Nyssorhynchus fuliginosus, variety *nagpori*, J. & L.
Nyssorhynchus fuliginosus, variety *adiei*, James.
Neocellia willmori, variety *maculosa*, James.

The following notes are necessary regarding certain of the names in the list. (1) Regarding *culicifacies*. In Vol. I of his monograph, page 183, Mr. Theobald described a species called *indica*, which in Vol. III, page 41, he stated was identical with *culicifacies*. We have, therefore, not entered *Myzomyia indica* in the list; *Neocellia indica* is an entirely different species. (2) Regarding *listoni*. Mr. Theobald has recently again adopted the name *christophersi* for this species. The name *listoni*, however, is the one by which the species has been commonly known in India for a number of years; it is known by that name to tea planters in malarious districts of the Duars and other parts of India. We consider, therefore, that it would be wrong to change its name. It appears to us that when a species has become well known under a certain name (and especially when it has become well known under that name to non-medical men) the name should be retained even if it happens not to be the name first given to the species. From page 75 of Vol. III of his monograph we gather that Mr. Theobald is of the same opinion. (4) Regarding *leptomeres*. This was described from a single specimen sent to Mr. Theobald by

Notes on the list.

Captain Christophers. We regard it as *culicifacies* or a variety of that species. (5) Regarding *punctulata*. The mosquito described by us in the first edition of this book, page 84, as *punctulatus*, Dönitz, is not that species. We have, therefore, changed the name to *punctulata*, James & Liston. (6) Regarding *maculipalpis*. Mr. Theobald (Vol. IV, page 98) is apparently of opinion that our Indian *maculipalpis* is not identical with the African *maculipalpis* described by Colonel Giles. We have, therefore, changed the name from *maculipalpis*, Giles, to *maculipalpis*, James & Liston. We find that our description on page 95 of the first edition is an accurate one for the Indian species and that it is accurate also for some specimens received from China. (7) Regarding *sinensis*, *nigerrimus*, &c. The mosquito that we described in the first edition, page 79, under the title *nigerrimus*, Giles, is the common *nigerrimus* of India, well known by that name to all workers. According to Mr. Theobald, however, it is not the *nigerrimus* that Col. Giles described and we have, therefore, been obliged to change its name to *nigerrimus*, James & Liston. We believe that it is identical with *sinensis*, Wiedmann. We have examined specimens from China (the habitat of Wiedmann's species) and can detect no difference between them and our *nigerrimus*. Moreover we have examined a number of specimens in the Indian Museum that were identified by Mr. Theobald, some as *sinensis*, some as *vanus* and some as *nigerrimus*. There is no difference between any of those specimens. Since the identifications were made Dr. Annandale (Superintendent of the Indian Musuem) has informed us that Mr. Theobald now regards *sinensis* and *vanus* as identical. Colonel Giles's *nigerrimus*—which is said to have black tipped palpi—has not been found by any other observer in India, and it is probable that he was dealing with what is now regarded as the common *nigerrimus* of India, but that in the specimen from which his description was drawn up the usual palp markings were indistinct. There is no doubt that *minutus*, Theobald (which was described from a single specimen sent by Captain Christophers) is also identical with *nigerrimus*, James & Liston. The final result therefore works out to, *sinensis*, Wiedmann = *vanus*, Walker = *nigerrimus*, James & Liston = *nigerrimus*, Giles = *minutus*, Theobald. When this synonymy is known it is of little consequence which name is used, but according to rule *sinensis* is the correct name. On the other hand, the line of argument mentioned

Notes on the list.

under (2) above inclines us to prefer the name *nigerrimus*, by which the mosquito has been commonly known in this country for some years. In order to meet the difficulty as far as possible and to aid in gradually introducing the correct name we shall throughout this edition refer to the mosquito as *sinensis*, Wiedmann = *nigerrimus*, James & Liston. (8) The names and descriptions of one or two species found since this list was made will be given in an appendix to Part II.

CHAPTER II.

THE COLLECTION, MOUNTING AND EXAMINATION OF ANOPHELINE MOSQUITOES AND THEIR LARVÆ.

The collection of adult Anopheles.—The collection of the so-called “domestic” species—that is, those species which are never found far from the neighbourhood of human habitations—is, as a rule, an easy matter provided search for them is made in the right places. The majority of the known species rest during the day-time in houses, stables and sheds, and in such haunts they may be easily captured by gently placing the open mouth of a test-tube over them as they rest on the walls or roof. A slight movement of the tube while it is kept pressed against the wall or roof will rouse the mosquito and make it fly towards the closed end of the tube, the mouth of which can then be closed by insinuating a cotton-wool plug between it and the wall or roof. Mosquitoes caught in this manner can be kept in the test-tubes, or if a large number are required, as for the purpose of dissection, it is preferable to transfer them from the test-tubes into a large bottle with a narrow neck (such as an empty white glass wine bottle), so that the test-tubes can be used again. In this way, if anophelines are at all plentiful, fifty or sixty can be caught in a very short time.

But before commencing the search for adult mosquitoes of this kind it is advisable carefully to select a suitable place. A native village with breeding places near (such as a stream, or canal, or ponds) should be chosen if possible. In such a village there will probably be several old unoccupied huts and sheds, and it is in these a good catch is most likely to be made. It is almost useless to search in a new house with whitened walls. The best place of all is in an old house with smoke-blackened thatched roof and mud walls. It is better to look first in an unoccupied house, because the smoke from the wood fires in houses where people are living, drives most of the mosquitoes out during the day-time into the nearest empty house

The collection of Mosquitoes.

or shed. Cowsheds in the middle of a village, native carpenters' shops, wood sheds, and the barracks of native soldiers, are also good places in which to search for anopheline mosquitoes.

In houses with high roofs it may be necessary to mount a ladder in order to examine each section of the thatch. The darker corners, the angles between the rafters and the thatch, and the cobwebs hanging from the roof, are favourite resting places of these mosquitoes. The commoner species, such as *rossi*, are usually seen at once, because they are light-coloured and large and stand out against the black background of soot like little white thorns hanging from the roof, but the smaller darker coloured species are difficult to see. *Culici-facies*, for example, hides most successfully in holes and corners of the roof, and in many places it would be possible to catch several hundred specimens of *rossi* in the time that it would take to catch fifteen or twenty specimens of that species. A difficulty also arises in collecting specimens of that very important species, from the fact that, as it does not assume the characteristic attitude of the majority of anopheline mosquitoes when resting on a wall or roof, it is very liable to be mistaken for a small brown "culex." For this reason, as well as for the reason that several species of unspotted winged anophelines occur in India, it is advisable, in rooms which are badly lighted, to catch all the mosquitoes that are seen, without taking note at the time whether they are "culex" or anopheles." As each mosquito is caught, the tube containing it can be taken to the light, and the mosquito carefully examined before transferring it to the large bottle.

In occupied houses and in barracks and hospitals, anophelines are likely to be found on dark-coloured clothes hanging in the corners of the rooms or in the cupboards, or resting on the under-surface of the shelves which usually surround the walls of barrack-rooms. Saddles and harness of all kinds are also favorite resting places of this kind of mosquito, and in the harness rooms of the cavalry regiments at Mian Mir as many as twenty or thirty can often be seen resting on the under-surface of each saddle hanging up in the rooms.

In stables and out-houses of Indian villages, it is usual for the natives to store a number of dried mud and straw cakes which are used for repairing their houses, and if one of these heaps of mud cakes is kicked over, a large number of anophelines will often fly out. In

The collection of Mosquitoes.

such a case as this a muslin net will be found very useful for catching the mosquitoes as they fly out. With one sweep of the net it is often possible to catch ten or twelve *culicifacies* after disturbing one of these heaps, when it may be difficult to find any specimens of this species resting on the walls or roofs of the houses.

In addition to collecting the species which are commonly found in the neighbourhood of habitations, it is very important to search for those species which are seldom or never found in houses and which may be termed "wild" species. They may sometimes be caught by the following method :—On a night when there is little or no wind a white sheet is hung near the ground under some trees, and a lighted lamp is placed on the ground in front of the sheet. The mosquitoes are attracted by the lamp and alight on the white sheet, when they may be caught by placing a test-tube over them in the usual way. Another plan is to erect a tent in the jungle or other place where we wish to search for these mosquitoes. After a day or two several will almost certainly be found in the corners of the tent and beneath the folds of its hangings. This method is of great service in villages where the inhabitants are unwilling to permit search being made in their houses.

The collection of larvæ.—The collection of adult mosquitoes should be supplemented by collecting the larvæ, which may be kept and bred out into adult mosquitoes.

Pools and streams frequently contain anopheline larvæ when none can be seen on the surface of the water, and, therefore, the method of "dipping" should always be employed for their collection.

One of the best things with which to dip for larvæ is a large tin mug, but a calico or muslin net with a long handle is of advantage for fishing in the middle of a pool or stream. Besides the dipper and net, a number of wide-mouthed bottles should be taken when going out to search for larvæ. When any collection of water is reached, the dipper should be scooped along the surface, under the grass or weed at the edge, and brought out full of water. If any larvæ have been caught they can easily be recognised in the dipper when they rise to the surface, and they should then be transferred with some of the water and weed into one of the wide-mouthed bottles. In running streams care should be taken to dip several times in the eddies and beneath the

How to mount Mosquitoes.

grass overhanging the edge of the water, as in such places larvæ are most likely to be found. The larvæ from different breeding places should be kept in separate bottles, in order that when they have been bred out and identified, the character of the breeding places of the different species will be known.

In searching for larvæ, it is important to note that no collection of water should be passed over without careful examination, for it often happens that the most unlikely-looking collection of water will yield many larvæ.

Each wide-mouthed bottle should be half-filled with water from the pool or stream in which the larvæ were taken. In some cases,—especially in the case of larvæ collected from running streams—it is necessary to change the water daily if healthy larvæ are to be reared. The mouths of the bottles are covered with fine muslin or mosquito netting, and allowed to stand in a warm place, but bright sunlight should be avoided. Each day the adult mosquitoes which have developed from the larvæ may be transferred to a clean dry bottle, in which they should be allowed to remain alive for twelve hours in order that they may attain their proper colour and size. After this period they may be killed and mounted for examination.

The mounting of Anophelines.—In making a collection of mosquitoes it is desirable to get as perfect specimens as possible, and for this reason the anophelines which have been caught as adults or have been bred from larvæ, should not be kept alive in the bottles longer than is necessary, lest by rubbing their wings against the glass when flying about, some of the scales may be rubbed off. The insects are best killed by suspending in the jar a small piece of cotton-wool moistened with chloroform. The plug of wool should not be dropped into the jar, but should be hung by a thread and pulled out when the mosquitoes are stupefied. Tobacco smoke should not be used for killing mosquitoes as it alters the colour of the markings. Immediately after the insects are dead, they should be turned out on to a clean sheet of cork carpet. If left too long exposed to the fumes of chloroform, the legs become fixed in awkward positions and brittle. Great care should be taken not to touch the insects with the fingers or some of the fine scales will be rubbed off, and if it is necessary to move any of them, a fine needle or pin should be used for the

How to mount Mosquitoes.

purpose. In order to mount mosquitoes the following articles are necessary :—

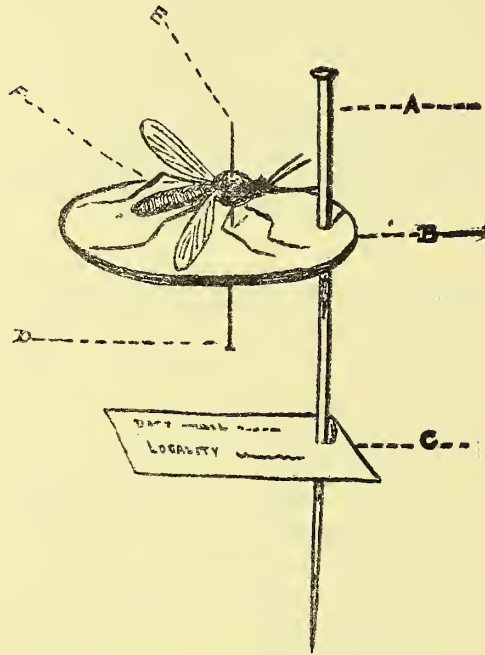


Fig. 4 (After Theobald).

(1) Fine entomological silver pins (No. 20 size).

(2) A pair of forceps for holding the pins.

(3) Common pins.

(4) Small discs of thin cardboard such as are used for gun wads, the size of a 20-bore gun.

(5) A drying box, in the floor of which is fixed a layer of cork carpet or pith, into which the pins can be inserted and firmly fixed.

A card-disc should be taken, and all the data concerning the specimen to be mounted, should be written upon it. Then one of the No.

20 pins should be firmly grasped near its point with the forceps and thrust through the centre of the disc until about half its length projects through it. The mosquito, which is lying dead on the sheet of cork, should be turned on its back with the aid of a pin, and, holding the head of the pin carrying the cardboard disc between the thumb and first finger of the right hand, the point of the pin is thrust into the thorax of the mosquito between the points of origin of the legs, and pressed on-wards until it emerges through the dorsal surface of the thorax. When the pin and disc are lifted off the cork and inverted, the mosquito will be in its natural position, right side upwards. The wings and legs may now be carefully arranged with the aid of a fine pin, but this is often unnecessary, and if all the parts can be seen moderately well, it is best not to touch them, as even the most careful manipulation will rub off some of the scales and hairs. An ordinary pin is thrust through the card-disc near its margin for the purpose of attaching it to the cork in the floor of the drying box. (See Fig. 4).

The above is the method of mounting mosquitoes usually adopted

An improved method of mounting.

in museums, but the use of card-discs has many disadvantages and therefore we think it advisable to describe in addition the following improved method. The use of pith instead of card-discs was suggested to Colonel Alcock, I.M.S., by Dr. Kertesz, the Hungarian entomologist, and as real pith cannot be obtained in India, Colonel Alcock substituted for it the Indian *sola*, which is the floating stem of a water plant (*Aeschynomene aspera*) common in Bengal. The stems are cylindrical and usually measure about 1 inch in diameter and 3 feet in length. They are used for making topees and can be obtained from hatters, a large bunch costing about one rupee. Obtain some of these stems and with a heavy very sharp knife cut them into rectangular blocks about half an inch long, half an inch deep, and a quarter of an inch broad. Now take some No. 20 silver pins and cut off their heads in a slanting direction with sharp scissors. Mount the mosquitoes on the pins in the usual way, but without using card-discs. Let an equal length of the pin project from the dorsum and from the venter. Now stick either the point or the head end of the pin into one of the blocks of *sola* and through another part of the block push an ordinary long pin for fixing the specimen in the entomological box. The long pin also carries (below the block) slips of paper on which particulars of the specimen are written. The advantages of this method will be noted when we come to deal with the examination of mosquitoes.

In India, mosquitoes very quickly become covered with mould, and in order to prevent this, and to preserve them properly, they should be thoroughly dried and then kept in the small glass tubes shown in fig. 5.

A flat cork (D) fitting very tightly is first pressed into the tube to its end. On this cork a small muslin bag (C) containing naphthalene and another containing calcium chloride are placed. These are kept in position by means of a cardboard disc perforated with holes (B) which is fastened firmly by pins to the cork in the bottom of the tube. The disc or pith carrying the mosquito (A) is pinned to the cork which closes the mouth of the tube. By this method mosquitoes may be preserved in good condition for a

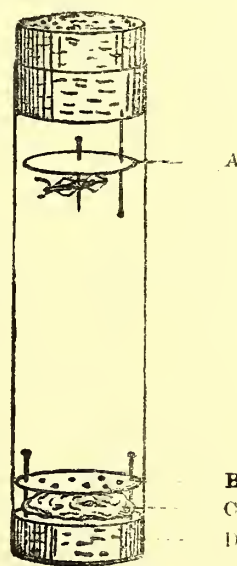


Fig. 5.

A plan for a type Collection.

long time, and if the tubes are well packed in a tin box with cotton-wool, they may be sent through the post with safety.

In addition to mounting male and female specimens of each species in the manner just described, it is necessary to have certain parts of each species mounted separately on glass slides. These parts are the wings, the legs, the male genitalia, and the male and female unguis (especially the unguis of the fore leg in the male).

The wings and legs are best mounted dry beneath thin coverslips, which may be kept in place by strips of gummed paper. The wings and legs should, of course, be mounted perfectly flat.

The male genitalia and the unguis should be mounted beneath thin coverslips in xylol balsam.

The following arrangement has been adopted by one of us for his *type collection* of species. A board of thick card or wood measuring $1\frac{1}{2}$ feet by 1 foot is covered with black paper firmly pasted on. Elastic bands passing through the board hold in place the following preparations: (1) a tube containing a complete female specimen pinned on a small block of *sola* pith, (2) a tube containing a complete male specimen pinned by the same method, (3) a tube containing a female specimen from which the wings, legs and abdomen have been removed, (4) a slide on which the wings are mounted dry beneath a cover-glass, (5) a slide on which the legs are mounted in the same way, (6) a slide on which the male genitalia and unguis are mounted in balsam, (7) a slide on which the abdomen is mounted dry beneath a cover-glass raised on small feet made of *sola* pith, (8) when necessary a slide or slides on which are mounted separately the scales from certain parts of the abdomen, thorax, or head, (9) when necessary a slide of one of the prothoracic lobes mounted dry beneath a cover-glass. Stuck on the lower left hand corner of the board is a card on which is printed the generic and specific name of the mosquito, the locality where the specimens were caught, the collector's name and the date of collection; and stuck on the lower right hand corner is an open envelope containing small cards on which are drawn important markings of the specimens and the arrangement and shapes of scales on the abdomen, thorax and head. The envelope also contains slips of paper on which different observers who have examined the preparations have recorded their findings, localities where they have found the same species, etc. This plan of arranging the specimens of a type collection has been approved by

The examination of Mosquitoes.

the Committee for the Study of Malaria in India, and is being adopted for the type collection at the Central Malaria Bureau, Kasauli.

The examination of adult Anophelines.—For the examination of adult mosquitoes a microscope with a two-thirds inch objective and a high power eyepiece (No. 8 or No. 12) is necessary. If the mosquito to be examined has already been mounted on a card-disc in the usual manner, it must be fixed by a pin thrust through the edge of the card-disc to a flat cork about an inch square. This piece of cork carrying the mosquito is placed on the microscope stage, and can be moved about at will (fig. 6). The angle at which the pin is fixed in the cork should be such that the part of the mosquito which is being examined is always as nearly as possible parallel to the microscope stage. When the mosquito has been mounted on a card-disc this essential rule is difficult

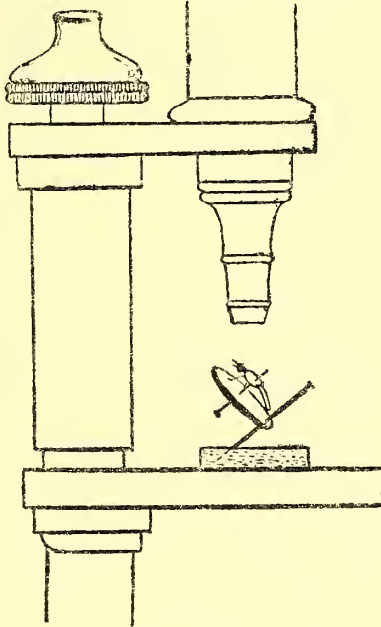


Fig. 6.

to carry out as regards every part of the specimen, and it will also be seen at once that the card-disc prevents entirely the examination of the ventral surface of the mosquito. It will be found also that when the large pin is slanted at the angle necessary for examining the lateral surface of the mosquito the edge of the disc prevents us from focussing the objective upon that surface. But when the mosquito has been mounted on a block of "pith" by the method already described these difficulties do not present themselves. In the first place, it will be seen from the drawing marked A, below, that in order to place the part under examination parallel to the microscope stage, it is not necessary to slant the large pin at various angles; instead of doing so, we thrust a second large pin through the block at right angles to the first pin, and when necessary a third pin at an angle of 45° to the first pin. In the second place, it will at once be seen that for the examination of the ventral surface of the mosquito all we have to do is to grasp the silver pin that carries the mosquito in the forceps, withdraw it from the pith and remount the mosquito upside down. (Fig. C). Also

How to describe a Mosquito.

that for the examination of any other part of the mosquito it can be mounted on the pith at any angle necessary.

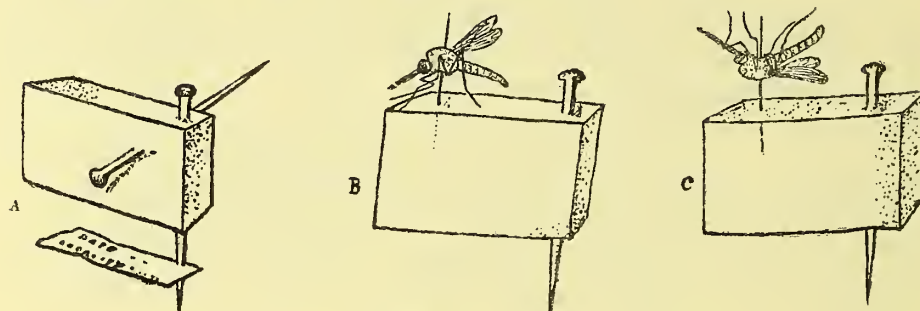


Fig. 6a.

In giving a complete description of a mosquito, it is usual to begin with an examination of the palpi, proboscis, and antennæ, and to work backwards, noting every marking and character that presents itself. The character of the antennæ will at once show whether the mosquito is a male or female, and the length and characters of the palpi whether it is a "culex" or an "anopheles." (See Pl. IV, figs. 1 to 4). In the examination of the palpi it will also be noted whether they are uniformly coloured or whether they are encircled with white bands, and the number, relative size, and position of any such bands will be described. (See coloured plates). In addition to definite bands a few white scaled patches may be present on one or more segments of the palpi as in *maculipalpis* and *stephensi*. Passing on to the examination of the head, the characters of the different groups of scales will be noted, and in particular the characters of the upright forked scales can be readily made out. In most species a prominent tuft of white hairs projecting forwards from the anterior angle of the head will be seen. The thorax will next be examined, and on its dorsal surface a large number of scales and a few hairs will probably be present. The characters of these scales and hairs are of importance in identification and should be carefully described. The examination of the prothoracic lobes will be directed to ascertaining whether they carry hairs only or whether they carry in addition a cocade or tuft of scales. Passing on towards the abdomen, the scutellum will be examined. In addition to the long bristles which will be readily seen attached to its border, the scutellum sometimes carries a few scales similar to those on the thorax. The bare horse-shoe shaped metanotum will next be

How to describe a Mosquito.

seen, and then the halteres, the knobs of which are sometimes clothed with numerous small silvery scales.

The examination of the abdomen is of great importance. In many species, although the abdomen is thickly covered with long hairs, no scales are present. In some species, however, it will be seen that in addition to the hairs covering the majority of the segments, a few golden-brown or dark-coloured scales can be made out, especially on the last one or two segments only. In other species, again, it will be at once seen that the whole surface of the abdomen is thickly set with white or golden-brown scales, which in some species are very broad (as in *pulcherrima*), and in others long and narrow (as in *stephensi*). It will readily be recognised that the presence or absence and the character of these abdominal scales is a very important aid in the determination of species. They will be further referred to in the chapter on classification.

The wings and legs will next be examined.

The most useful way of describing the wing markings is by means of a diagrammatic drawing giving the number and relative size and position of the different dark and light-scaled areas on each vein. The detailed shape of the wing scales, which is a point of some importance, and the relative position of the transverse veins must be noted by a separate examination of a wing mounted under a cover-glass.

The legs should be examined in order, and a careful description of the markings on each leg, commencing with those on the femur and ending with those of the fifth tarsal segment, made. It will be seen that in many species complete bands of white scales encircle the legs near the joints, and the position and characters of these bands should be noted. In addition, small patches of white scales, not amounting to complete bands, will be found in some species on many of the segments of the legs ("speckling"), and in some species one or more of the terminal tarsal segments of the hind legs will be found to be white-scaled in their whole length.

The description will be completed by an examination of the male genitalia and of the unguis (special note being taken of the characters of the fore unguis in the male), these structures being separately mounted on slides for this purpose.

How to study Scales.

The examination of scales.

To study the detailed structure and shape of scales it is necessary to mount them flat on slides. The following is the simplest way and though much more elaborate methods have been devised it will be found sufficient for all purposes. Dissect from its surrounding structures the part of the mosquito that carries the scales it is desired to study. This must be done by clean cuts with a very sharp knife or most of the scales will be rubbed off in the process. Place the part that carries the scales on a slide beneath a cover-glass. Tap and press the cover-glass so as slightly to crush the part of the mosquito. Then remove the cover-glass and with the point of a needle slide away the part of the mosquito and all the large particles of debris. Replace the cover-glass and fix it with strips of gummed paper. During the manipulations many scales will have remained on the slide. Examine them with a high power objective and draw some of them with the aid of an eyepiece camera lucida. Scales that are black may be mounted in Canada balsam, but in this medium most scales are so transparent that they are seen with difficulty. It will be found that with care and practice almost any part of a mosquito can be dissected out and placed by itself on a slide. The prothoracic lobes of the species in which these lobes are provided with a cocade of scales make interesting microscopic preparations. When an anopheline has become thoroughly dry they can be removed by a little manipulation with the point of a needle inserted behind them in the groove where they are attached to the thorax. For the removal of the legs and wings it is also essential that the mosquito should be thoroughly dry; otherwise difficulty will be experienced and many of the scales will be rubbed off. The anterior promontory of the thorax is another part that makes a good specimen because it usually carries scales that differ in shape from those on the main area of the dorsum.*

The mounting and examination of larvæ.—The larvæ of mosquitoes may be examined when alive or when killed and mounted on slides. In order to examine a larva when it is alive it is caught in a small spoon—care being taken not to injure it—and transferred with a drop of water on to a glass slide. A cover-glass is then dropped very gently

*Captain Christophers has recently perfected a method of mounting mosquitoes which shows the scale structure better than any other method we have seen. It will be described in the Appendix to Part II.

The examination of Larvæ.

on to it. This has the effect of preventing the larva from continually wriggling out of the field of the microscope, and, if carefully done, it does not break any of the larval hairs or injure it in any way.

Larvæ should be killed by covering the dish of water to which they have been transferred with a piece of blotting paper soaked in formalin. They may be mounted by placing them in a solution of formalin in hollow ground glass slides, applying a cover-glass and ringing it with thick Canada balsam, or by the following more permanent method, first recommended by Dr. Christophers—

- (a) Kill the larva by immersing it in strong formalin solution, and allow it to remain in this solution for at least twelve hours.
- (b) Immerse the larva after treatment in the formalin solution, in absolute alcohol for fifteen minutes.
- (c) Immerse it in oil of cloves.
- (d) Clear with xylol and mount on an ordinary flat slide under a cover-glass in xylol balsam.

During the above process very great care must be taken to handle the larvæ gently so as not to break any of the finer hairs. They are best removed from one dish to another by lifting them up very gently on the edge of a piece of stiff paper.

Another plan, which shows the palmate hairs and some other characters of the larvæ exceedingly well, consists in mounting the cast larval skins. These skins are very transparent, but they can be seen without difficulty floating near the surface of the vessel of water in which the larvæ are kept.

It is of advantage to be able to identify the different anopheline species by an examination of their larvæ. Grassi was the first to show that this could be done for some of the Italian species, and work by the members of the Royal Society's Malaria Commission in India has shown that the majority of the known Indian species can also be differentiated in the larval stage of their existence.

The structures by which the larvæ of different species may be identified are :—

(1) *The Frontal or Clypeal hairs* (Pl. III, A & C).—These are four fine hairs which project from the dorsal surface of the anterior end of the head. They may be called the external and the median frontal hairs. The external hairs are placed one at each corner of the dorsal chitinous end of the head, and exactly overhang the prominent

The examination of Larvæ.

so-called whorl organs or "shaving brushes." When the whorl organs are pushed out, the external (corner) hairs are difficult to see, but when the whorl organs are drawn in, they stand out prominently. The median hairs arise close together near the middle line and project forward in front of the head. They are easily seen under a $\frac{1}{4}$ or $\frac{1}{2}$ inch objective.

A very important difference between the larvæ of different species depends upon the fact that the characters of these external and median frontal hairs differ in different species. The details of these differences are given in Part II, under the descriptions of the several species.

(2) *The Palmate hairs* (Pl. III, A & B).—If the dorsal surface of the abdomen of an anopheline larva is examined under the microscope, a pair of little fan-shaped organs will be seen on the majority of the segments. These are the so-called "Palmate hairs." Each consists of a short stalk surmounted by a bundle of about 15 to 18 hairs which are arranged round the stalk like the petals of a flower. When the larva comes to the surface these leaflets spread out and form a series of little cup-shaped organs which serve to keep the larva floating in the horizontal position. Both the number of the palmate hairs and the shape of each leaflet differ in different anopheline species, so that observations upon them serve as a second means of distinguishing the larvæ of different species.

(3) *The Antennæ* (Pl. III, A).—These structures are very easily recognised, and in the majority of Indian species they differ but little. A very small hair should be noted on the outer side of the antenna at about the junction of its middle and lower third in the majority of the larvæ.

The larvæ of several Indian species, however, are readily distinguished from those of any other species by the presence of a stout branching hair on the inner side of each antenna, quite distinct from the small external hair referred to above. The characters of this large branching hair are shown in the diagram of the larva of *barbirostris* (Plate V, Fig. 1, A and D). In another species (*lindesayi*) a similar but smaller branching hair is present.

(4) *The pattern of the head markings*.—Although the pattern on the dorsal surface of the head of anopheline larvæ is formed by dots of pigment only, and is therefore liable to considerable variation, yet in some species the head pattern is sufficiently constant to be of assist-

Larval variations.

ance in the identification of larvæ. The inverted triangular area enclosing four dots of pigment on the dorsal surface of the head of the larva of *rossi*, for example, is very characteristic (Pl. VI, Fig. 1, A), as is also the complete absence of any pattern on the head of the larvæ of *stephensi* (Pl. VI, Fig. 2, A). The usual markings on the heads of these and other larvæ are given in the diagrams.

(5) *The Basal hair*.—We have already described in Chapter I the position of this hair. Its shape and character are particularly remarkable in the larvæ of *culiciformis* and at once serve to differentiate the larvæ of this species from all others.

(6) *The Posterior hair*.—In some larvæ, as we have already mentioned, two hairs arise from the clypeus behind and between the frontal hairs. In the larvæ of *turkhudi* (Pl. VIII, Fig. 2) these hairs are unbranched and very long. In the larvæ of *jeyporiensis* (Pl. VII, Fig. 2) they are short but branched.

It should be noted that in the identification of any particular larva, too much stress should not be laid on any one of the above structures alone, but that a careful consideration of the characters of all the structures taken together will yield the most accurate results. This is necessary because, as has been shown by a number of observers, the characters of the frontal hairs may vary even among a series of larvæ from the same batch of eggs. It is particularly to be noted also that the size and to some extent the other characters of larvæ depend upon whether the conditions of life have been favourable or not. The larvæ of *stephensi* taken by Dr. Bentley in the Bombay wells at a water level 20 to 30 feet from the surface were invariably very small and bore no resemblance as regards naked eye characters to the large larvæ of the same species taken in open shallow pools. The adult insects bred from the small larvæ of wells were also much smaller than those bred from larvæ taken in open water and at first sight it appeared as if they were a different species, but when examined microscopically no important differences in structure or markings could be detected. Captain Christophers has observed the effect of similar unfavourable conditions of life upon larvæ and adults taken in the Punjab.

The examination and identification of eggs.—In order to obtain eggs of anophelines it is necessary to preserve some female mosquitoes of this kind that have been caught in a native village, until they have

The examination of eggs.

deposited their eggs. The best method of keeping mosquitoes alive for this purpose is that recommended by Drs. Stephens and Christophers. A glass "chutney" or "pickle" jar with a wide mouth and a hollow glass stopper is obtained, and after it has been thoroughly cleaned and dried a piece of cardboard is placed in it of such a size that after being forced into the jar it remains firmly fixed (Fig. 7). The stopper is filled nearly to the brim with water, and a thin piece of cork covered with white paper is put to float in it. The mosquitoes that have been caught (both males and females) are transferred from the collecting tubes into the jar, which is then placed upside down upon the stopper in a dark cupboard. If mosquitoes from a village are used, it will usually be found that even after one night some of them will have deposited their eggs. Some of the eggs will almost always be found on the white paper, which can then be removed and placed on the microscope stage, the eggs being examined by reflected light with a half or two-thirds inch objective.

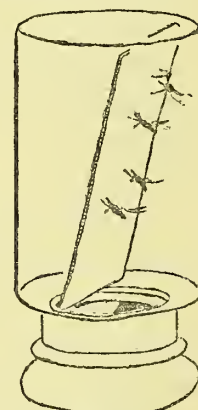


Fig. 7.
(After Stephens and Christophers.)

Great care should, of course, be taken that all the mosquitoes in the jar are of the same species, for, if more than one kind is introduced, it will be impossible to tell to which species the eggs belong.

The points to which attention should be directed in the examination of an anopheline egg are :

(1) *The upper surface.*—The width of the upper surface should be carefully measured, and it should be especially noted whether the floats almost touch each other on this surface, or whether their inner edges are wide apart.

(2) *The floats.*—The character, size and extent of the floats should be noted, and it should especially be seen whether their inner edges encroach on the upper surface of the egg, or whether the floats are inserted laterally so that their inner edges are wide apart on the dorsum of the egg.

(3) *The rim or frill.*—It should be noted whether the rim is wide or narrow and whether the floats appear to arise from it, or whether they arise behind it, in which case it would be continued uninterruptedly round the upper surface of the egg.

Types of eggs.

(4) *The lower surface.*—It should be noted whether the lower surface is smooth and uniformly coloured, or whether it is marked with silvery lines dividing it into a number of polygonal areas.

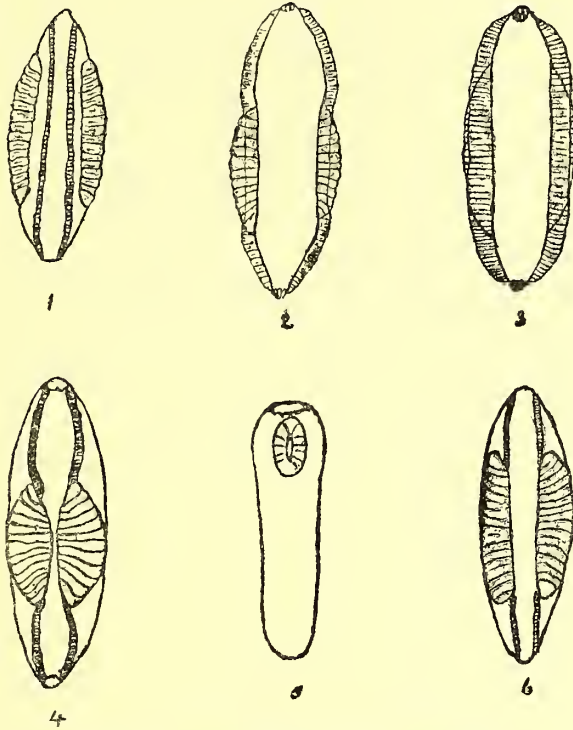


Fig. 8. (After Stephens and Christophers.)

1 *culicifacies*. 2 *pulcherrima*. 3 *rossi*. 4 *stephensi*. 5 *turkhudi*. 6 *maculipalpis*.

Types of Ova.

The following types of anopheline ova have been described by Drs. Stephens and Christophers :—

Type 1.—Ova having the upper surface very narrow, the rim or frill being continued uninterruptedly round this surface and the lateral floats not touching its margins (Fig. 8, 1.)

Some species with ova of this type are :—*culicifacies*, *listoni*, *barbirostris*, *nigerrimus*.

Type 2.—Ova having a more or less broad upper surface with the lateral floats touching its margins and apparently arising from the frill (Fig. 8, 2, 3, 4, 6.)

Types of eggs.

Some species with ova of this type are :—*rossi*, *pulcherrima*, *fuliginosus*, *stephensi*.

Type 3.—Ova with no floats and with the upper surface rudimentary (Fig. 8, 5.)

Only one species, *viz.*, *turkhudi*, is at present known to have ova of this type.

Further details regarding the ova of different species will be found in Part II.

CHAPTER III.

THE CLASSIFICATION AND IDENTIFICATION OF INDIAN ANOPHELINES.

The following tabular statement shows (1) the names of the groups or genera in which the anopheline mosquitoes of India are at present arranged by Mr. Theobald, and (2) the characters by which Mr. Theobald identifies the genera and distinguishes them from one another.

Genus.	Abdominal ornamentation.	Thoracic ornamentation.	Form of wing scales.	Form of head scales.
<i>Anopheles</i> , Meigen	Hair like curved scales.	Hair like curved scales.	Large and lanceolate.	Upright forked, but no flat scales.
<i>Myzomyia</i> , Blanchard.	"	"	Mostly small, long and narrow or slightly lanceolate.	"
<i>Stethomyia</i> , Theobald.	"	"	Lanceolate.	Median area of head with some flat scales.
<i>Pyrelophorus</i> , Blanchard.	Hairy.	Narrow curved scales.	Small and lanceolate.	Not stated.
<i>Myzorchynchus</i> , Blanchard.	Apical ventral tuft of scales.	Hair like curved scales.	Dense large lanceolate.	Not stated.
<i>Nyssorchynchus</i> , Blanchard.	Lateral tufts and small dorsal patches of flat scales.	Narrow curved or spindle shaped scales.	Not stated.	Not stated.
<i>Neomyzomyia</i> , Theobald (1910.)	Only the last segment carries scales.	Anterior promontory with a group of curved scales. Remainder of dorsum hairy. Prothoracic lobes with a tuft of scales.	Not stated.	Broadly expanding upright forked scales which form dense tufts at the posterolateral corners.
<i>Cellia</i> , Theobald.	Nearly completely scaled with long irregular scales and with lateral tufts.	With scales.	Not stated.	Not stated.
<i>Neocellia</i> , Theobald	Similar to <i>Cellia</i> but no lateral tufts.	With scales.	Not stated.	Not stated.
<i>Aldrichia</i> , Theobald.	Completely scaled with large flat scales as in <i>culex</i> .	With scales.	Not stated.	Not stated.

It has to be noted also that in 1907 Mr. Theobald stated that the common Indian species *rossi* cannot be placed in any of these genera

Species without abdominal scales.

and that a genus *Pseudomyzomyia* would be created for its reception. He has not yet published the characters of this genus, and in Vol. V of his monograph, published in 1910, he still refers to the species as *Myzomyia rossi*, so we must suppose that he has abandoned the intention to create a new genus for it.

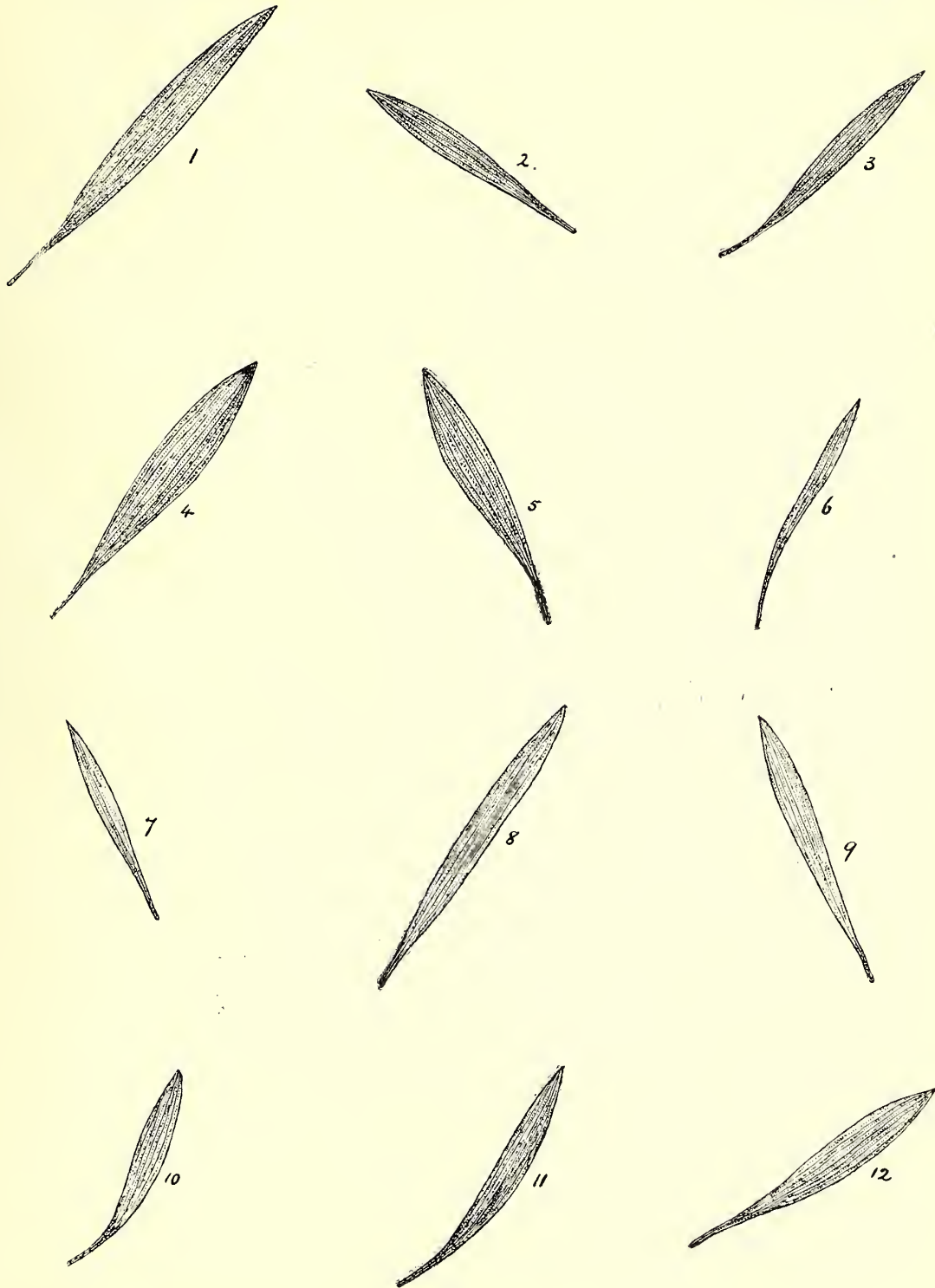
A careful examination of the above table will convince the reader that it would be very difficult, if not impossible, correctly to arrange the Indian species generically by its aid. Those who have worked at the subject will be aware also that some of the defining descriptions can be criticised as being (1) incorrect, *e.g.*, the description of the abdominal ornamentation in the genus *Nyssorhynchus*; there are no lateral abdominal scale tufts on mosquitoes of this genus, (2) inadequate, *e.g.*, the descriptions of the characters of the genera *Cellia*, *Neocellia*, etc., (3) indefinite, *e.g.*, the descriptions of the forms of wing scales. The difficulties caused by these defects have led to much criticism of the system of classifying the *Anophelinae* on a basis of scale and hair covering, but it is probable that the fault lies not so much with the system as with the nature of the generic definitions. In this revision we shall try to avoid similar defects, but limits of space prevent us from giving more than a very brief summary of our work and for the same reason we are prevented from explaining in full why we differ from Mr. Theobald in some points of detail.

A consideration of the best way in which to arrange the Indian anophelines according to scale and hair ornamentation is simplified if one starts by separating all the species in two great groups, the first containing those without scales on the abdomen and the second containing those with scales on some part or the whole of that region of the body. According to our present knowledge of species the following come in the first of these groups:—

Species without scales of any kind on the abdomen.	{	<i>aitkeni</i> , James.
		<i>immaculatus</i> , Theobald.
		<i>culiciformis</i> , James and Liston.
		<i>barianensis</i> , James.
		<i>lindesayi</i> , Giles.
		<i>gigas</i> , Giles.
		<i>simlensis</i> , James.
		<i>culicifacies</i> , Giles.
		<i>listoni</i> , Liston.
		<i>leptomeres</i> , Theobald.
		<i>jeyporiensis</i> , James.
		<i>turkhudi</i> , Liston.
		<i>nigri-fasciatus</i> , Theobald.
		<i>nursei</i> , Theobald.

To face page 38.

PLATE V.



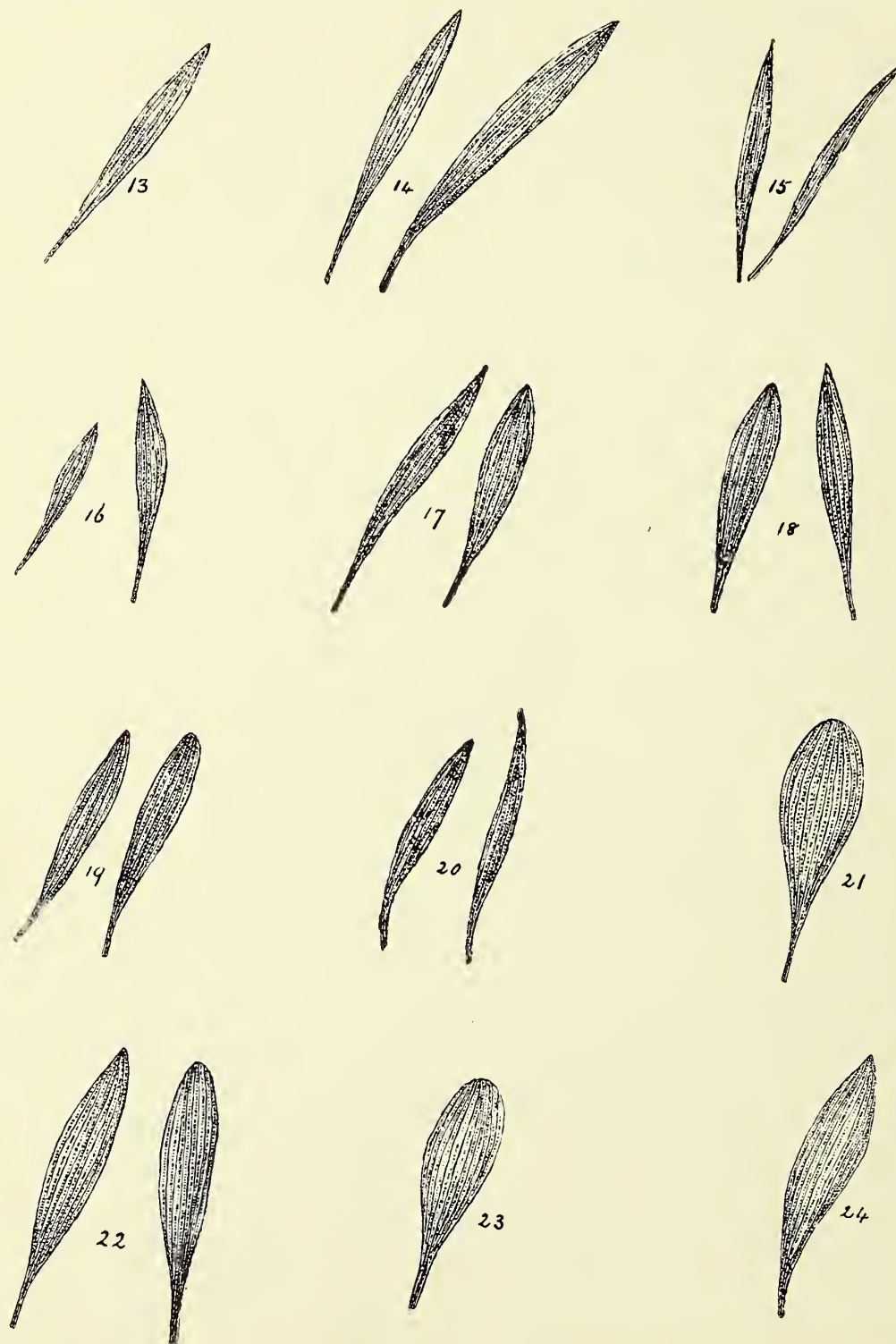
Wing scales of *Anophelines*. 1. *maculipennis*; 2. *bifurcatus*; 3. *aitkeni*; 4. *gigas*; 5. *lindesayi*; 6. *culicifacies*; 7. *listoni*; 8. *turkhudi*; 9. *rossi*; 10. *maculatus*; 11. *fuliginosus*; 12. *jamesi*.





To face page 39.

PLATE VI.



Wing scales of *Anophelines*. 13. *theobaldi*; 14. *maculipalpis*; 15. *jeyporiensis*; 16. *elegans*; 17. *stephensi*; 18. *willmori*; 19. *indica*; 20. *intermedia*; 21. *barbirostris*; 22. *nigerrimus*; 23. *pulcherrima*; 24. *halli*.

Species without abdominal scales.

Such of these species as were known to Mr. Theobald were placed by him in the following groups or genera—

In the genus *Anopheles* : *aikeni*, *immaculatus*, *lindesayi* and *gigas*.

In the genus *Stethomyia* : *culiciformis*.

In the genus *Myzomyia* : *culicifacies*, *listoni*, *leptomerus* and *turkhuhi*.

In the genus *Pyretophorus* : *jeyporiensis*, *punctulata*, *nigri-fasciatus* and *nursei*.

A study of many specimens of these and other species has led to the following chief conclusions :—

(1) We have carefully examined specimens of the European species *maculipennis*, Meigen, and *bifurcatus*, Linnaeus, and taking them as the types of the genus *Anopheles* we are able to place in that genus three Indian species at present known to us, namely, *barianensis*, *immaculatus* and *turkhuhi*. (2) We find that the reported distinguishing character of the genus *Stethomyia*, namely, the presence of a few “flat scales” on the head is not confined to the species now placed in that genus; it is a character common to anophelines that differ widely in more important scale characters. It will be remembered that the original character upon which this genus was founded, namely, the possession of mammilated prothoracic lobes, was observed by Mr. Theobald and others to be not distinctive, and now that the second character has been found to be not distinctive the genus should, in our opinion, be sunk. (3) The shape of wing scales as a means of distinguishing between the genera of this first large group of anophelines appears to us to be an unsatisfactory means of distinction. We place here two plates of wing scales carefully drawn under the same magnification and it appears to us that they prove the contention just advanced. Nevertheless we find that the character is the only one by which a separation of the genera *Anopheles* and *Myzomyia* can be made, and that unless it is agreed to sink one or other of these two genera we must accept it until a better distinguishing character is found. (4) We believe that the Indian Anophelines without scales on the abdomen can be arranged in groups based on characters much more distinctive and easily recognised than those Mr. Theobald has chosen.

For the arrangement of the species without scales on the abdomen we retain three of Mr. Theobald's groups, namely, *Anopheles*,

Genera 1 to 3.

Myzomyia and *Pyretophorus*, and create two new groups called respectively *Neostethopheles* and *Patagiamyia*. The following definitions include the characters by which the groups may be identified and distinguished from one another.

Genus 1. *NEOSTETHOPHELES*, nov. gen. Abdomen with hairs but without scales of any kind. Thorax with hairs and, as a rule, without scales of any kind, but, in one or two species a few long, exceedingly narrow false scales may be present chiefly on the anterior promontory. Prothoracic lobes with hairs but without scales. Upright forked scales of the head very narrow in their whole length (linear or rod shaped.)

Type of the genus: *aitkeni*, James. The distinguishing characters of the genus are shown in Plate A.

We place the following species in this genus:—

aitkeni, James,
culiciformis, James and Liston.

Genus 2. *ANOPHELES*, Meigen. Abdomen with hairs but without scales of any kind. Thorax with the dorsum clothed with hairs and with very narrow, sharp-pointed, curved, tapering scales. Prothoracic lobes with hairs but without scales. Upright forked scales of the head of the usual anopheline type, that is broadly expanding from the base to the apex. Wing scales rather large, broadest in the middle, gradually and almost equally tapering towards the sharp-pointed apex and towards the base.

Type of the genus: *maculipennis*, Meigen. We place the following Indian species in it:

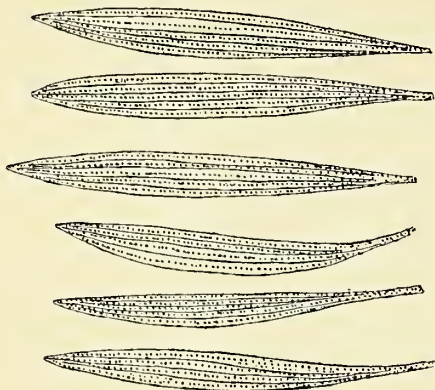
barianensis, James (The Indian type species).
immaculatus, Theobald.
turkhudi, Liston.

The genus differs from the next one, *MYZOMYIA*, in the character of the wing scales only. Except between the type species of the genera, namely, *maculipennis* and *culicifacies* the difference is not very great and it may sometimes be difficult to say definitely in which genus a species should be placed. We therefore give a separate plate showing the wing scales of the two European and of three of the Indian species.

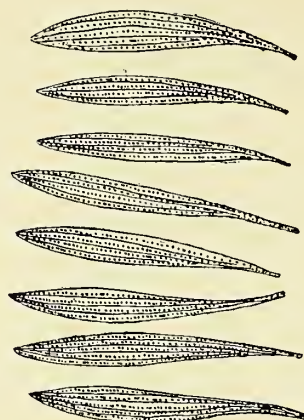
Genus 3. *MYZOMYIA*, Blanchard. Abdomen with hairs, but without scales of any kind. Thorax with the dorsum clothed with long, very narrow, sharp-pointed, curved scales more numerous anteriorly and forming on the anterior promontory a bunch projecting over the neck.



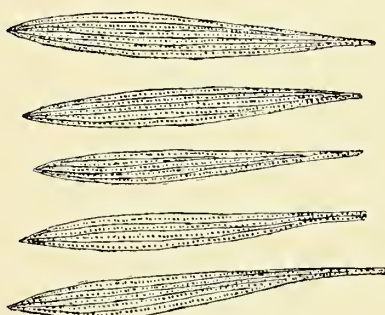
Anopheles maculipennis.



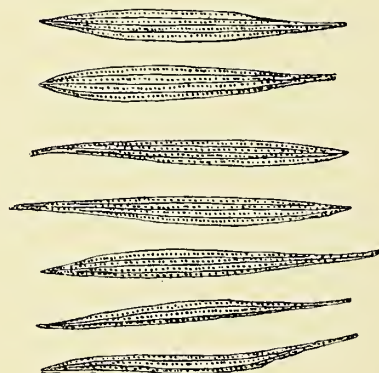
Anopheles bifurcatus.



Anopheles barianensis.



Anopheles buckhudi.



Myzomyia culicifacies.



Myzomyia listoni.



To show the shape of the wing scales in the genera *Anopheles* and *Myzomyia*.

Genera 4 and 5.

Prothoracic lobes with hairs but without a tuft of scales. Upright forked scales of the head of the usual anopheline type, that is broadly expanding from the base to the apex. Wing scales very narrow, broadest towards the apex, tapering acutely towards the apex, gradually towards the base.

Type of the genus: *culicifacies*, Giles. The distinguishing characters of the genus are shown in Plate A.

We place the following species in the genus:—

culicifacies, Giles,
listoni, Liston,
leptomeres, Theobald.*

It is usual to place *turkhudi* in this genus, not in the genus *Anopheles*. In our opinion the great majority of the wing scales of that species are broadest in the middle and taper gradually towards the apex and base; they much resemble the wing scales of *Anopheles bifurcatus*. In size, general appearance, and habits the species is also much nearer to *maculipennis* than to *culicifacies* or *listoni* and by regarding it as an *Anopheles* rather than as a *Myzomyia* we attain a much more natural grouping of the different species.

Genus 4. *PATAGIAMYIA*, nov. gen. *Abdomen with hairs, but without scales of any kind. Thorax with the dorsum clothed with long, narrow, curved, sharp-pointed scales which form on the anterior promontory a thick bunch projecting over the neck. Prothoracic lobes with a conspicuous tuft of rather broad true scales projecting anteriorly. Upright forked cephalic scales of the usual broadly expanding type.*

Type of the genus: *gigas*, Giles. The other Indian species in the genus are *lindesayi*, Giles and *simlensis*, James. The distinguishing generic characters are shown in Plate A.

Genus 5. *PYRETOPHORUS*, Blanchard. *Abdomen with hairs, but without scales of any kind. Thorax and scutellum with moderately broad, rather short, true scales, mostly sharp-pointed and slightly curved, but some blunt ended (ob-lanceolate). Prothoracic lobes with hairs and sometimes with a very few scales scattered irregularly, but always without a bunch or tuft of scales. Upright forked cephalic scales of the usual broadly expanding type.*

Indian type example of the genus: *jeyporiensis*, James. The generic characters are shown in Plate A.

* When a species is marked with an asterisk it means that we have not examined its scale ornamentation in detail and that it is placed in the genus only provisionally.

Species with abdominal scales.

We place the following species in the genus:—

jeyporiensis, James,
nigrifasciatus, Theobald,*
nursei, Theobald.*

We now take up the arrangement of the species which have scales on some part or the whole of the abdomen. At present 18 of these species are usually classified in Mr. Theobald's genera as follows:—

In the genus <i>Nyssorhynchus</i>	..	..	..	<i>maculatus</i> , Theobald. <i>fuliginosus</i> , Giles. <i>jamesi</i> , Theobald. <i>theobaldi</i> , Giles. <i>maculipalpis</i> , James and Liston. <i>karwari</i> , James. <i>stephensi</i> , Liston. <i>willmori</i> , James.
In the genus <i>Myzorhynchus</i>	..	..	..	<i>barbirostris</i> , Van der Wulp. <i>sinensis</i> , Wiedmann. <i>nigerrimus</i> , James and Liston. <i>nigerrimus</i> , Giles.
In the genus <i>Cellia</i>	..	..	..	<i>pulcherrima</i> , Theobald.
In the genus <i>Neocellia</i>	..	..	..	<i>indica</i> , Theobald. <i>intermedia</i> , Rothwell. <i>dudgeonii</i> , Theobald.
In the genus <i>Neomyzomyia</i>	..	..	..	<i>elegans</i> , James.
In the genus <i>Aldrichia</i>	..	..	..	<i>error</i> , Theobald.

Rossi, Giles, for which Mr. Theobald proposed a genus called *Pseudomyzomyia*, and *halli*, James, which is a new species only recently assigned to a genus, are not included in the list; they will be considered separately in this account.

For the arrangement of the species in this second large group—the group in which scales are present on the abdomen—we retain the names of the groups *Nyssorhynchus*, *Myzorhynchus*, *Cellia*, *Neocellia* and *Neomyzomyia*, but we alter Mr. Theobald's definitions of these groups so as to make them represent clearly the scale characters of the groups. In the second place, we change the position of one or two species that have been placed in wrong groups, and, in the third place, we create two new groups, one for *rossi*, the other for *halli*. We are unable to say anything about the genus *Aldrichia*, as we have not seen the specimen which represents it.

Dealing first with the group *Nyssorhynchus* we agree with Mr. Theobald in regarding the Indian species *maculatus* as a suitable type of a group of anophelines characterized by the presence of scales on

Genera 6 and 7.

only the last one, two, or three segments of the abdomen, and we find that the scale structure of this species agrees in all important respects with that of *fuliginosus*, *jamesi*, *maculipalpis*, *theobaldi* and *karwari*. Our definition of the group characters is as follows :—

Genus 6. NYSSORHYNCHUS, Blanchard. *Abdomen with the first five or six segments ornamented with hairs only. The last three or two segments and the genital processes carry in addition a number of rather long blunt-ended true scales on both the dorsal and ventral surfaces. On the 8th segment and the genital processes the scales may be arranged in patches or may cover the surface more or less evenly ; but they are never aggregated together to form tufts of any kind. Thorax with the dorsum covered with quite broad true scales usually arranged in more or less parallel lines. On the anterior promontory the scales are long and sharp-pointed and form a small bunch projecting over the neck on each side of the middle line ; on the mid region and posteriorly they are broader and some are blunt-ended. The scutellum carries a number of similar scales. Prothoracic lobes without a tuft of scales. Head with the usual kind of upright forked scales.*

Type of the genus, *maculatus*, Theobald. The generic characters are shown in Plate B.

We place the following species in this group :—

maculatus, Theobald,
fuliginosus, Giles,
jamesi, Theobald,
theobaldi, Giles,
karwari, James,
maculipalpis, James and Liston.

We have next to consider the species *rossi*, which in its scale ornamentation exhibits some of the characters of the group *Myzomyia* and some of the group *Nyssorhynchus*. An examination of a large number of specimens of this mosquito has shown that, although minor differences in the degree and character of the scale ornamentation are common, the chief features as figured in Plate B, can always be made out on unrubbed specimens. We describe them thus :

Genus 7. NYSSOMYZOMYIA, nov. gen. *Abdomen with the first seven or six segments ornamented with hairs only. The eighth segment (sometimes also the seventh) and the genital processes carry in addition a number of scales similar in character and arrangement to those of the group Nyssorhynchus. Thorax with the dorsum clothed with hairs and*

Genera 7 and 8.

narrow, curved, sharp-pointed, scales of various lengths and quite similar to those of the group *Myzomyia*. In addition there are on each side of the anterior third of the dorsum and beneath the angles of the anterior promontory some broader blunt-ended scales. Prothoracic lobes without a tuft of scales. Head with the usual type of upright forked scales.

The species is therefore representative of a group intermediate between *Myzomyia* and *Nyssorhynchus*, and is nearer to the latter than to the former group. The term NYSSOMYZOMYIA suitably indicates that it possesses the characters of both groups and we therefore apply this name to the genus instead of the name *Pseudomyzomyia* which Mr. Theobald proposed. The other species at present in this group are *ludlowi*, Theobald and *punctulata*, James and Liston.

We have now to consider a new genus quite recently created by Mr. Theobald for the reception of *elegans*, James. We define the characters thus :

Genus 8. *NEOMYZOMYIA*, Theobald. Abdomen with the first seven segments ornamented with hairs only. The eighth segment and the genital processes carry in addition a number of scales arranged like those of the genus *Nyssorhynchus*. Thorax chiefly clothed with hairs but the anterior promontory carries a group of sharp-pointed scales. Prothoracic lobes with a tuft of long broad outstanding scales. Head with the upright forked scales forming dense tufts at the postero-lateral corners.

This genus differs from any of those that we have described. The description of the thoracic covering and the presence of a cocade of scales on the prothoracic lobes are reminiscent of the genus *Patagiamyia*, but in that genus there are no scales on the abdomen. Apparently it comes nearest to the genus *Myzorhynchus*, Blanchard, the difference being that in *Myzorhynchus* the abdominal scales are arranged as a ventral tuft. The name *Neomyzomyia* is misleading.

We take up next the group *NEOCELLIA*, Theobald, several members of which have usually been wrongly placed in the genus *Nyssorhynchus*. The characters of this group are very different from those of the group *Cellia* and the name *Neocellia* is therefore quite misleading. *Neonyssorhynchus* would have been a more suitable name, but the resemblance even to that group is not close.

The type species of the group is the Indian species *indica*, Theobald. We define the group characters thus :

Genera 9 and 10.

Genus 9. *NEOCELLIA*, Theobald. Abdomen with the dorsum of each segment clothed irregularly with hairs and long, rather broad, blunt-ended, scales. The scales are not aggregated together to form tufts of any kind, but they are more numerous and thickly set on the last two segments than on the others. On the ventral surface the first five segments are devoid of scales, but on this surface of the 6th, 7th, and 8th segments they are present in considerable numbers, being disposed irregularly but attached chiefly on each side of the mid line and not forming tufts of any kind. Thorax clothed with broad true scales. Prothoracic lobes with or without a few scales irregularly disposed, but always without a definite bunch or tuft of scales. Head with the usual type of upright forked scales.

The characters of this genus are shown in Plate C. We place the following species in it:—

indica, Theobald,
stephensi, Liston,
willmori, James,
intermedia, Theobald,*
dudgeonii, Theobald.*

Lastly we have to consider the arrangement of the species in which some of the abdominal scales are disposed so as to form distinct bunches or tufts projecting from the dorso-lateral or from the ventral surface of certain segments. These tufts form conspicuous objects readily seen with a hand-lens, and their presence supplies an easy means of separating the following groups from any of those described above. The Indian species provided with certain of these abdominal tufts of scales are (1) *pulcherrima*, Theobald, (2) *sinensis*, Wiedmann, (3) *nigerrimus*, James and Liston (which perhaps = *sinensis*, Wiedmann and *vanus*, Walker), (4) *nigerrimus*, Giles, (5) *barbirostris*, Van der Wulp, (6) *halli*, James; and they must be arranged in three quite distinct groups the names of which are (1) *Cellia*, Theobald, (2) *Myzorhynchus*, Blanchard, and (3) *Christophersia*, nov. gen.

The following are our definitions of these groups:—

Genus 10. *CELLIA*, Theobald. Abdomen with the dorsum of each segment clothed with very large and broad orbicular and square-ended scales which stand out somewhat from the surface and overlap one another. In addition at the postero-lateral corner of each segment from the 1st to the 7th is inserted a bunch of large scales forming a tuft which projects laterally. Six tufts on each side are plainly visible with a weak lens. The ventral surface of each segment is clothed more or less evenly with

Genera 11 and 12.

very broad scales like those of the dorsum, but the clothing is not so thick as on that surface. The postero-lateral tufts of the dorsal surface are visible on each side, but there are no ventral tufts of scales projecting downwards. Thorax clothed with very broad scales. Prothoracic lobes with or without a few scales projecting forwards.

Type species of the genus, *pulcherrima*, Theobald.

Genus 11. *MYZORHYNCHUS*, Blanchard. Abdomen with the dorsal surface clothed with hairs only. On the ventral surface from the apex of the seventh segment in the middle line a prominent bunch or tuft of rather long, black, true scales projects downwards. On the ventral surface of the 6th, 5th, 4th and 3rd segments a few small white scales may be present; if so they are arranged somewhat irregularly and do not form tufts. Thorax with the dorsum clothed with hairs and narrow, sharp-pointed, scales like those in the genus *Myzomyia*. Prothoracic lobes with a dense tuft of broad true scales projecting anteriorly. Head with short very broadly expanding upright forked scales.

Type species of the genus, *sinensis*, Wiedmann. The generic characters are shown in Plate D. The other species in the genus are *nigerrimus*, James and Liston, and *nigerrimus*, Giles and *barbirostris*, Vander Wulp.*

Genus 12. *CHRISTOPHERSIA*, nov. gen. Abdomen with the dorsum of each segment thickly clothed with hairs and narrowly elliptical and blunt-ended scales which are not aggregated together to form tufts of any kind. The ventral surface of each segment is devoid of scales except that from the apices of six segments in the mid line prominent tufts of long, blunt-ended, scales project directly downwards. These tufts resemble the single abdominal tuft present in the genus *Myzorhynchus*. Thorax clothed with rather narrow oblong and blunt-ended true scales. Prothoracic lobes with a prominent tuft of true scales. Head with the usual kind of upright forked scales.

Type of the genus: *halli*, James. The generic characters are shown in Plate D.

It remains now to summarize in tabular form the essential differences between the groups we have defined and to show in the form of a second table the changes made in the generic position of the different Indian species.

*The abdominal scale ornamentation of this species differs slightly from the type; it may have to be placed in a sub-genus.

Key to the genera.

Table of generic characters.

	Genus.	Abdomen.	Thorax.	Prothoracic lobes.	Upright forked scales of the head.
WITHOUT SCALES ON ABDOMEN.	NEOSTETHOPHELES, <i>nov. gen.</i>	With hairs but without scales.	With hairs but without scales. (The presence of a few long, sharp-pointed, very narrow scales on the anterior promontory does not exclude a species from this genus.)	With hairs but without scales.	Of a characteristic rod-shaped type not broadly expanding towards the apex.
	ANOPHELES, Meigen.	With hairs but without scales.	With hairs and long narrow sharp-pointed curved tapering scales.	With hairs but without scales.	Of the usual broadly expanding type. [Note. Wing scales broadest in the middle and tapering almost equally towards apex and base.]
	MYZOMYIA, Blanchard.	With hairs but without scales.	With long narrow, sharp-pointed curved scales on the whole dorsal surface but more numerous anteriorly.	Without a tuft of scales.	Of the usual broadly expanding type. [Note. Wing scales very narrow, broadest near the apex, tapering acutely towards the apex, gradually towards the base.]
	PATAGIAMYIA, <i>nov. gen.</i>	With hairs but without scales.	With long, narrow, sharp-pointed scales more numerous anteriorly.	With a conspicuous tuft of broad scales.	Of the usual broadly expanding type.
	PYRETOPHORUS, Blanchard.	With hairs but without scales.	With quite broad true scales some of which are blunt-ended.	Without a tuft of scales.	Of the usual broadly expanding type.
WITHOUT ABDOMINAL SCALE TUFTS.	NYSSORHYNCHUS, Blanchard.	The dorsal and ventral surfaces of the last 3 or 2 segments carry true scales which are not aggregated to form tufts.	With short broad true scales.	Without a tuft of scales.	Of the usual broadly expanding type.
	NYSSOMYZOMYIA, <i>nov. gen.</i>	With the last or the last 2 segments carrying true scales as in the genus <i>Nyssorhynchus</i> .	With long, narrow, sharp-pointed scales as in the genus <i>Myzomyia</i> , and with some broader, short scales.	Without a tuft of scales.	Of the usual broadly expanding type.

Key to the genera.

Table of generic characters.—contd.

	Genus.	Abdomen.	Thorax.	Prothoracic lobes.	Upright forked scales of the head.
WITHOUT ABDOMINAL SCALE TUFTS.	NEOMYZOMYIA, Theobald (1910).	Only the last segment carries scales.	With hairs and sharp-pointed curved scales.	With a tuft of true scales.	Of the usual type but forming tufts at the postero-lateral angles.
	NEOCELLIA, Theobald.	The dorsal surface of every segment carries true scales which do not form tufts. The ventral surface of the last 3 or 2 segments carries scales which do not form tufts.	With broad true scales.	Without a tuft of scales.	Of the usual broadly expanding type.
WITH ABDOMINAL SCALE TUFTS.	CELLIA, Theobald.	The dorsal and ventral surfaces of every segment carry very broad scales. In addition tufts of large scales project outwards from the postero-lateral corners of the dorsal surface of each segment. No ventral tufts of scales.	With very broad true scales.	With or without a few scales projecting forwards.	Of the usual broadly expanding type.
	MYZORHYNCHUS, Blanchard.	The dorsal surface clothed with hairs only. The ventral surface with a conspicuous tuft of true scales projecting directly downwards from the apex of the seventh segment in the mid line.	With long, sharp-pointed scales like those of the genus <i>Myzomyia</i> .	With a dense tuft of true scales.	Of the usual broadly expanding type.
	CHRISTOPHERSIA, <i>nov. gen.</i>	The dorsal surface of each segment carries scales which do not form tufts. The ventral surface with six prominent tufts of true scales projecting directly downwards from the mid line.	With moderately broad true scales.	With a prominent tuft of scales.	Of the usual broadly expanding type.

The generic position of Indian species.

Table of species.

Specific name.	Genus according to Mr. Theobald's Monograph of the Culicidæ.	Genus according to the arrangement described here.
<i>aikeni</i> , James.	<i>Anopheles</i> .	<i>Neostethopheles</i> .
<i>immaculatus</i> , Theobald.	<i>Anopheles</i> .	<i>Anopheles</i> .
<i>culiciformis</i> , James and Liston.	<i>Stethomyia</i> .	<i>Neostethopheles</i> .
<i>barianensis</i> , James.	—	<i>Anopheles</i> .
<i>gigas</i> , Giles.	<i>Anopheles</i> .	<i>Patagiamyia</i> .
<i>simlensis</i> , James.	—	<i>Patagiamyia</i> .
<i>lindesayi</i> , Giles.	<i>Anopheles</i> .	<i>Patagiamyia</i> .
<i>culicifacies</i> , Giles.	<i>Myzomyia</i> .	<i>Myzomyia</i> .
<i>listoni</i> , Liston.	<i>Myzomyia</i> .	<i>Myzomyia</i> .
<i>leptomeres</i> , Theobald.	<i>Myzomyia</i> .	<i>Myzomyia</i> .*
<i>turkhudi</i> , Liston.	<i>Myzomyia</i> .	<i>Anopheles</i> .
<i>elegans</i> , James.	<i>Myzomyia</i> , 1903. <i>Pyrethophorus</i> , 1907 <i>Neomyzomyia</i> , 1910.	} <i>Neomyzomyia</i> .*
<i>jeyporiensis</i> , James.	<i>Pyrethophorus</i> .	
<i>punctulata</i> , James and Liston.	—	<i>Pyrethophorus</i> .
<i>nigrifasciatus</i> , Theobald.	<i>Pyrethophorus</i> .	<i>Nyssomyzomyia</i> .
<i>nursei</i> , Theobald.	<i>Pyrethophorus</i> .	? <i>Pyrethophorus</i> .*
<i>maculatus</i> , Theobald.	<i>Nyssorhynchus</i> .	? <i>Pyrethophorus</i> .*
<i>fuliginosus</i> , Giles.	<i>Nyssorhynchus</i> .	<i>Nyssorhynchus</i> .
<i>jamesi</i> , Theobald.	<i>Nyssorhynchus</i> .	<i>Nyssorhynchus</i> .
<i>theobaldi</i> , Giles.	<i>Nyssorhynchus</i> .	<i>Nyssorhynchus</i> .
<i>maculipalpis</i> , James and Liston.	—	<i>Nyssorhynchus</i> .
<i>indiensis</i> , Theobald.	<i>Nyssorhynchus</i> .	<i>Nyssorhynchus</i> .*
<i>karwari</i> , James.	<i>Nyssorhynchus</i> .	<i>Nyssorhynchus</i> .
<i>rossi</i> , Giles.	<i>Myzomyia</i> , 1903. <i>Pseudomyzomyia</i> , 1907.	<i>Nyssomyzomyia</i> .
<i>ludlowi</i> , Theobald.	<i>Myzomyia</i> .	<i>Nyssomyzomyia</i> .
<i>indica</i> , Theobald.	<i>Neocellia</i> .	<i>Neocellia</i> .
<i>intermedia</i> , Rothwell.	<i>Neocellia</i> .	<i>Neocellia</i> .*
<i>stephensi</i> , Liston.	<i>Nyssorhynchus</i> .	<i>Neocellia</i> .
<i>willmori</i> , James.	<i>Nyssorhynchus</i> .	<i>Neocellia</i> .
<i>dudgeonii</i> , Theobald.	<i>Neocellia</i> .	<i>Neocellia</i> .*
<i>pulcherrima</i> , Theobald.	<i>Cellia</i> .	<i>Cellia</i> .
<i>barbirostris</i> , Van der Wulp.	<i>Myzorkhynchus</i> .	<i>Myzorkhynchus</i> .
<i>sinensis</i> , Wiedmann.	<i>Myzorkhynchus</i> .	<i>Myzorkhynchus</i> .
<i>nigerrimus</i> , James and Liston.	<i>Myzorkhynchus</i> .	<i>Myzorkhynchus</i> .
<i>nigerrimus</i> , Giles.	<i>Myzorkhynchus</i> .	<i>Myzorkhynchus</i> .
<i>halli</i> , James.	—	<i>Christophersia</i> .
<i>error</i> , Theobald.	<i>Aldrichia</i> .	*

How to determine the genus.

Described varieties are not included in this list and the synonyms are not mentioned. The complete list of Indian species and varieties at present known has already been given in Chapter I.

We now proceed to the identification of anophelines, taking up first the determination of the genus.

How to ascertain the generic position of an anopheline. (1) Using a microscope with a two-thirds inch objective and a high power eyepiece (No. 8 or No. 12) examine the dorsal, lateral, and ventral surfaces of the abdomen of the mosquito. If scales are not seen at once, search carefully the last segment and the abdominal processes. Upon the care with which the examination of the abdomen is carried out depends in large measure the accuracy of the subsequent determination. If no scales are found the mosquito belongs to one of the following genera: *Neostethopheles*, *Patagiamyia*, *Anopheles*, *Myzomyia*, *Pyretophorus*. (2) Having determined that this is the case next examine the head. It will be seen at once whether the upright forked scales are of the usual broadly expanding type (all the spotted winged anophelines of India have scales of that type), or whether the upright forked scales are very narrow in their whole length (rod-shaped or, if we follow botanical nomenclature, linear). If they are of the latter kind the mosquito belongs to the genus *Neostethopheles*. (3) If the upright forked scales are of the usual broadly expanding type (obscagittate) next examine the prothoracic lobes from the dorsal aspect. To see one of them clearly slant the pin so that the mosquito is turned more or less on its side. A little practice will overcome any initial difficulty that may be experienced in obtaining a good view of one of these bodies. It will at once be seen whether or not the lobe is provided with a cocade of scales projecting anteriorly. If the lobe carries such a cocade the mosquito belongs to the genus *Patagiamyia*. (4) If a cocade of scales is not present on the lobe next examine the dorsal surface of the thorax. If the scales are long, sharp-pointed, and very narrow (that is if it is rather difficult to tell at a first glance whether they are scales or hairs) the mosquito belongs to the genus *Anopheles* or to the genus *Myzomyia*.* If the scales are short and quite broad the mosquito belongs to the genus *Pyretophorus*. To distinguish between the genera *Anopheles* and *Myzomyia* examine the wing scales

*By "the dorsal surface" we understand the main area of that surface; we exclude the anterior promontory.

How to determine the genus.

on the third long vein and a little beyond the bifurcations of the second and fourth veins. The characteristic features of the scales in each genus have already been mentioned and are shown clearly on the *plate of wing scales in the genera Anopheles and Myzomyia*.

Secondly, the initial examination of the abdomen will have shown that one or more of the abdominal segments carry scales as well as hairs. In that event proceed as follows: (1) The first point to decide is whether or not some of the scales are aggregated to form tufts. The appearance of these tufts is shown on Plate D; they are very definite objects and the mistake must not be made of regarding as tufts the irregularly disposed scales that in some species overhang the sides of the terminal abdominal segments. The only case in which a beginner might be uncertain about the presence or absence of a tuft is in regard to some specimens of the genus *Myzorhynchus*. In specimens of that genus the examination of the dorsal surface of the abdomen might not have shown the presence of any scales, and even when the ventral surface is being examined no scales might be detected because the black scales of the ventral tuft would be viewed against the equally black background of the abdomen. It is only when the mosquito has been turned round for the examination of the lateral surface that the tuft projecting from the apex of the seventh abdominal segment can be plainly seen. That is why it is so important at the initial examination of the mosquito to examine separately the dorsal, ventral and lateral surfaces. If the tuft referred to is present the mosquito belongs to the genus *Myzorhynchus*. (2) If the dorsal surface of the abdomen is seen to be clothed with very broad scales and that in addition each segment carries a pair of tufts (projecting laterally) the mosquito belongs to the genus *Cellia*. (3) If each segment of the dorsal surface is clothed with scales and hairs and if when the mosquito is turned on its side six prominent tufts are seen projecting from the mid line of the ventral surface the mosquito belongs to the genus *Christophersia*. (4) If the abdomen is not provided with a tuft or tufts of scales we have to decide whether the scales that are present are confined to the last few segments or whether every segment carries them. If the latter is the case the mosquito belongs to the genus *Neocellia*. If scales are present on only the last one, two, or three segments the mosquito belongs to the genus *Nyssorhynchus* or to the genus *Nyssomyzomyia* or to the genus *Neomyzomyia*. Examine the prothoracic lobes;

How to determine the species.

if they carry a cocade of scales the mosquito is a *Neomyzomyia*, if not it is either a *Nyssorhynchus* or a *Nyssomyzomyia*. To distinguish between them examine the dorsal surface of the thorax. If the scales are long, narrow and sharp-pointed as in the genus *Myzomyia* the mosquito belongs to the genus *Nyssomyzomyia*, if they are short and quite broad it belongs to the genus *Nyssorhynchus*.

The determination arrived at by these simple rules should in all cases be confirmed by examination of each region of the mosquito.

When the correct generic name of a specimen has been ascertained the remaining part of the task of identification is easy, because there are only a few Indian species in each genus. The distinctions between the species are based upon the markings on the wings, legs, and palpi, these markings being caused by patches of light and dark scales. The species enumerated in the list already given can be identified from the following tables:—

1. Genus NEOSTETHOPHELES.

<i>aitkeni</i> , James	..	..	..	..	Wings unspotted. Palpi with no trace of banding. The first sub-marginal cell of the wing is almost exactly double the length of the second posterior cell. Legs with no trace of banding.
<i>culiciformis</i> , James and Liston	..	..	..	..	Wings unspotted. A much larger mosquito than <i>aitkeni</i> , but palpi and legs entirely unbanded as in that species. Separate by examination of the wing, namely, that (1) the transverse veins are all in one line, which is not the case in <i>aitkeni</i> , (2) the first sub-marginal cell is less than double the length of the second posterior cell.

2. Genus PATAGIAMYIA.

<i>lindesayi</i> , Giles	..	..	..	..	Palpi unbanded. The femora of the hind legs have a broad white patch.
<i>gigas</i> , Giles	..	..	..	..	Palpi unbanded. The femora without a white patch. The wing spots also differ greatly (see figures).
<i>simlensis</i> , James	..	..	..	..	Palpi black tipped, but with three narrow white bands. For other differences see Part II.

Key to the species.

3. Genus ANOPHELES.

<i>barianensis</i> , James	..	..	..	Wings unspotted. Palpi unbanded. Easily distinguished from <i>aitkeni</i> and <i>culiciformis</i> by the presence of broadly expanding cephalic scales and from <i>immaculatus</i> by the absence of bands on the palpi.
<i>immaculatus</i> , Theobald	..	..	..	Wings unspotted. Palpi with a broad white band, including the tips, and two narrow ones. Tarsal segments have pale apical bands.
<i>turkhudi</i> , Liston	..	..	..	Wings spotted. Palpi black tipped, but with three white bands.

4. Genus MYZOMYIA.

<i>culicifacies</i> , Giles	..	..	..	The first (basal) costal spot of the wing is divided into two by a small white spot. The 3rd longitudinal vein is black scaled in almost its whole length. The 1st sub-marginal cell is less than half again as long as the 2nd posterior cell. The wing fringe has only two white areas.
<i>listoni</i> , Liston	..	..	..	The first costal spot is not divided. The 3rd longitudinal vein is white scaled in almost its whole length. The 1st sub-marginal cell is more than half again as long as the 2nd posterior cell. The wing fringe has five white areas.
<i>leptomeres</i> , Theobald	..	..	..	This species is <i>culicifacies</i> or a variety of it.

5. Genus PYRETOPHORUS.

<i>jeyporiensis</i> , James	..	..	..	A small mosquito like <i>listoni</i> . Palpi with white tips. Legs with tiny bands.
<i>nigrifasciatus</i> , Theobald	..	..	..	A large mosquito like <i>turkhudi</i> . Tips of palpi black. Legs unbanded.
<i>nursei</i> , Theobald	..	..	..	Like <i>nigrifasciatus</i> , but with white tipped palpi. Legs unbanded.

6. Genus NYSSORHYNCHUS.

A. PALPI WITH THREE WHITE BANDS.

<i>maculatus</i> , Theobald	..	..	..	Only the 5th hind tarsal segment is white. Legs speckled.
<i>theobaldi</i> , Giles	..	..	..	The 4th and 5th hind tarsal segments are white. Legs speckled.
<i>fuliginosus</i> , Giles	..	..	..	The 3rd, 4th and 5th hind tarsal segments are white. Legs not speckled.
<i>jamesi</i> , Theobald	..	..	..	Like <i>fuliginosus</i> , but the legs are speckled.
<i>maculipalpis</i> , James and Liston	..	..	..	Like <i>fuliginosus</i> , but legs and palpi speckled.

B. PALPI WITH FOUR WHITE BANDS.

<i>karwari</i> , James	The 5th hind tarsal segment is white. Legs not speckled.
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Key to the species.

7. Genus NYSSOMYZOMYIA.

<i>rossi</i> , Giles	Palpi with three bands. None of the hind tarsal segments white. Legs not speckled.
<i>ludlowi</i> , Theobald	..	..	..	..	Legs speckled. Palpi also differ. See Part II.
<i>punctulata</i> , James and Liston	Palpi with four white bands and speckling.

8. Genus NEOMYZOMYIA.

<i>elegans</i> , James	See description in Part II.
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9. Genus NEOCELLIA.

<i>indica</i> , Theobald	Palpi black tipped and with three white bands. The 5th hind tarsal segment white.
<i>willmori</i> , James	..	..	..	..	Palpi white tipped and with three white bands. The 5th hind tarsal segment white.
<i>stephensi</i> , Liston	..	..	..	..	Palpi white tipped and with three white bands. None of the hind tarsal segments white.
<i>dudgeonii</i> , Theobald	..	..	..	..	This species is probably <i>willmori</i> .
<i>intermedia</i> , Rothwell	..	..	..	..	This species is probably <i>stephensi</i> but said to have four palp bands.

10. Genus CELLIA.

<i>pulcherrima</i> , Theobald	Palpi with four white bands. The last three hind tarsal segments white.
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11. Genus MYZORHYNCHUS.

<i>barbirostris</i> , Van der Wulp	Palpi unbanded.
<i>sinensis</i> , Wiedmann	Palpi white tipped and with four white bands.
<i>nigerrimus</i> , James and Liston	..	..	..	..	This species is <i>sinensis</i> .
<i>nigerrimus</i> , Giles	Palpi said to have black tips, otherwise like <i>sinensis</i> .

12. Genus CHRISTOPHERSIA.

<i>halli</i> , James	Palpi with five white bands.
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To determine first the generic and then the specific name by the method just described is the correct zoological practice, but not everyone has sufficient leisure to study the subject of scale structure carefully, and for this reason it is fortunate that it is usually easy even without the aid of generic grouping to determine the correct specific name of a specimen; and this, of course, is the main object which the student of tropical medicine has in view. Those who decide to neglect the generic grouping of anophelines will be able to

Tables which neglect generic grouping.

ascertain the specific name of the common Indian anophelines by using the following tables. At the same time we strongly advise a careful examination of the scale structure of specimens before deciding upon their specific and generic names and we wish particularly to note that the tables now to be given will serve the purpose of giving only the probable name of a specimen.

I. WINGS UNSPOTTED.

A. PALPI UNBANDED.

<i>Neostethopheles aitkeni</i> , James	..	..	A small dark mosquito. Transverse veins of wing not in one line.
<i>Neostethopheles culiciformis</i> , James and Liston			A large brown mosquito. Transverse veins in one line.
<i>Anopheles bariensis</i> , James	..	..	The cephalic scales are of the usual broadly expanding type.

B. PALPI WITH WHITE BANDS.

<i>Anopheles immaculatus</i> , Theobald	Palpi with three white bands.
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II. WINGS SPOTTED.

A. PALPI UNBANDED.

<i>Patagiamyia lindesayi</i> , Giles	Costa of wing with one large spot at apex. Femora of hind legs with a broad white band.
<i>Patagiamyia gigas</i> , Giles	..	..	Costa of wing with several spots. Femora without broad band.
<i>Myzorrhynchus barbirostris</i> , Van der Wulp	..	..	With very densely scaled thick palpi.

B. PALPI WITH FIVE WHITE BANDS.

<i>Christophersia halli</i> , James	A golden brown species.
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C. PALPI WITH FOUR WHITE BANDS.

<i>Myzorrhynchus sinensis</i> , Wiedmann	..	{	.. Tarsal joints banded, but none of hind tarsal segments white. Tips of palpi white.
<i>Myzorrhynchus nigerrimus</i> , James and Liston			
<i>Myzorrhynchus nigerrimus</i> , Giles	..	..	As above but tips of palpi black.
<i>Cellia pulcherrima</i> , Theobald	..	..	Abdomen with broad white scales. Legs speckled. Last three hind tarsal segments white.
<i>Nyssomyzomyia punctulata</i> , James and Liston			Legs banded and speckled. None of hind tarsal segments white.
<i>Neomyzomyia elegans</i> , James	..	..	Legs banded and speckled. A very broad band at joint between femur and tibia of hind leg.
<i>Neocellia intermedia</i> , Rothwell	..	..	Resembles <i>stephensi</i> , but said to have four palp bands.
<i>Nyssorrhynchus karwari</i> , James	..	..	Legs banded but not speckled. The last hind tarsal segment white.

D. PALPI WITH THREE WHITE BANDS.

a. Tips of palpi black.

<i>Anopheles turkhudi</i> , Liston	..	..	None of the hind tarsal segments white.
<i>Pyreophorus nigrofasciatus</i> , Theobald	..	..	Very like <i>turkhudi</i> .

Tables which neglect generic grouping.

<i>Neocellia indica</i> , Theobald	..	..	The last hind tarsal segment white. Legs speckled.
<i>Patagiamyia simlensis</i> , James	..	..	Separate by wing markings.

b. Tips of palpi white.

One or more of the hind tarsal segments are pure white.	{	<i>Ny. fuliginosus</i> (Giles)	. . .	Tarsal joints banded; legs not speckled. The 3rd, 4th and 5th hind tarsal segments pure white.
		<i>Ny. jamesi</i> (Theobald)	. . .	As above, but with speckled legs.
		<i>Ny. maculipalpis</i> (Giles)	. . .	As above, but with legs and palpi speckled.
		<i>Ny. theobaldi</i> (Giles)	. . .	Only the 4th and 5th hind tarsal segments are pure white.
		<i>Ny. maculatus</i> (Theobald)	. . .	Only the 5th hind tarsal segment is pure white.
		<i>Neo. willmori</i> (James)	. . .	Differs from <i>maculatus</i> in having many scales on all segments of the abdomen.
Tarsal joints banded, none of the hind tarsal segments pure white.	{	<i>Neo. dudgeonii</i> (Theobald)	. . .	Very like <i>willmori</i> .
		<i>Ny-M. rossi</i> (Giles)	. . .	The legs are not speckled.
		<i>Ny-M. ludlowi</i> (Theobald)	. . .	Legs speckled.
		<i>Neo. stephensi</i> (Liston)	. . .	The legs and palpi are speckled. Abdomen covered with scales.
Legs uniformly coloured without bands or white segments.	{	<i>M. listoni</i> (Liston)	. . .	The third longitudinal vein of wing white-scaled. Six white patches on wing fringe.
		<i>Py. jeyporiensis</i> (James)	. . .	Seven white patches on wing fringe. Faint white spots at some of the joints of the legs.
		<i>M. culicifacies</i> (Giles)	. . .	Third longitudinal vein of wings black-scaled. Faint white spot at some of the joints of the legs.

An example or two will serve to illustrate the method of using this table.

Example 1. A mounted mosquito for determination.

Antennæ. With short inconspicuous hairs at the joints (Plate IV, figs. 2 & 4) showing that the mosquito is a female.

Palpi.—As long as the proboscis (Plate IV, fig. 4) showing that the mosquito is an anopheline.

Wings.—Spotted. The mosquito therefore comes under group II in the table.

Palpi.—With three white bands or rings, namely, one broad band including the tips (which are therefore white) and two others. The mosquito therefore comes in the group D, sub-group b.

Legs.—The tarsal joints are banded, but none of the hind tarsal segments is white in its whole length.

Key to larvæ.

The mosquito is therefore either *rossi*, *ludlowi*, or *stephensi*. If the legs and palpi are speckled with white patches it is *stephensi*, if the legs are not speckled it is *rossi*.

Example 2. A female anopheline.

Wings.—Spotted.

Palpi.—With three white rings, the outermost of which includes the tips. The outermost ring is broad and the others narrow. The mosquito comes in the group II, D, sub-group *b*.

Legs. The 3rd, 4th and 5th hind tarsal segments are white in their whole length. The legs are not speckled.

The mosquito is therefore *fuliginosus*.

The identification of Anopheline larvæ. In the following table the chief characters of the larvæ of some of the Indian anophelines are given:—

I. ANTENNÆ WITH A LARGE BRANCHED HAIR.

A. WITH SIMPLE UNBRANCHED FRONTAL HAIRS.

Patagiamyia lindesayi.

B. WITH BRANCHED FRONTAL HAIRS.

<i>Myzorhynchus barbirostris</i>	..	..	..	Median frontal hairs unbranched. The branches of the external frontal hairs arise from the main stem and from other branches.
<i>Myzorhynchus sinensis</i>	..	..	..	Median frontal hairs unbranched. The branches of the external frontal hairs arise from the main stem only.

II. ANTENNÆ WITHOUT A LARGE BRANCHED HAIR.

A. WITH FULLY DEVELOPED PALMATE HAIRS ON THE THORAX.

a. With simple unbranched frontal hairs.

<i>Myzomyia culicifacies</i>	..	..	..	The filaments of the palmate hair leaflets rather long.
<i>Myzomyia listoni</i>	..	..	..	Palmate hairs very large on thorax. Filaments shorter. Characteristic head pattern.
<i>Neostethopheles culiciformis</i>	..	..	..	Basal hairs characteristic.

b. With branched frontal hairs.

<i>Pyretophorus jeyporiensis</i>	..	..	..	Two branched posterior hairs in addition to the frontal hairs. Palmate hairs large. Filaments short.
<i>Nyssorhynchus maculipalpis</i>	..	..	..	No posterior hair.

Key to larvæ.

B. WITHOUT FULLY DEVELOPED PALMATE HAIRS ON THORAX.

a. With simple unbranched frontal hairs.

<i>Nyssomyzomyia rossi</i>	..	..	..	Characteristic head pattern. Filaments of leaflets long.
<i>Neocellia stephensi</i>	..	..	..	No head pattern. Filaments shorter.
<i>Nyssorhynchus theobaldi</i>	..	..	..	Filaments very short and blunt.
<i>Nyssorhynchus maculatus</i>	..	..	..	Filaments short sharp-pointed.
<i>Anopheles turkhudi</i>	..	..	..	Two long unbranched posterior hairs. Palmate hairs on only the last few abdominal segments.
<i>Nyssorhynchus karwari</i>	..	..	..

b. With branched frontal hairs.

<i>Nyssorhynchus fuliginosus</i>	..	..	..	Frontal hairs much branched.
<i>Cellia pulcherrima</i>	..	..	..	Frontal hairs only slightly branched or frayed.
<i>Neostethopheles aitkeni</i>	..	..	..	External frontal hairs unbranched, median forked.

We find that in the larvæ of common species some of the characters vary considerably and therefore for purposes of identification and classification we are not now inclined to attach very great importance to them.

PLATE A.

EXPLANATION

The figures show the position of the various points of observation on the coast of the island, and the points of observation on the coast of the island. The figures show the position of the various points of observation on the coast of the island, and the points of observation on the coast of the island.

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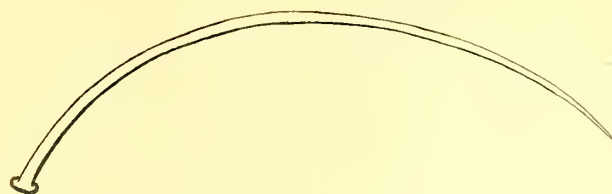
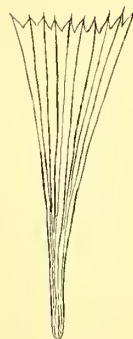
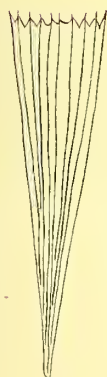
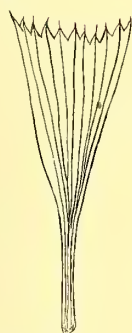
The figures show the position of the various points of observation on the coast of the island, and the points of observation on the coast of the island. The figures show the position of the various points of observation on the coast of the island, and the points of observation on the coast of the island.

PLATE A.
EXPLANATION.

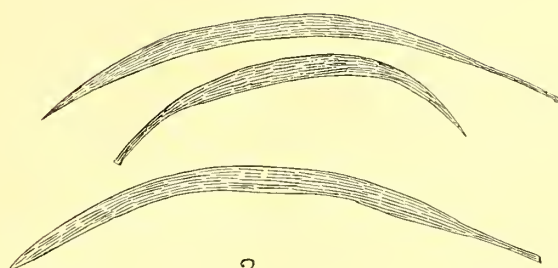
The figures show from left to right the upright forked scales of the head, the hairs or scales on the dorsum of the thorax, and the hairs or scales on the prothoracic lobes. The drawings of these structures relate respectively to

The genus	NEOSTETHOPHELES	(Fig. 1.)
„ „	MYZOMYIA	(Fig. 2.)
„ „	PATAGIAMYIA	(Fig. 3.)
„ „	PYRETOPHORUS	(Fig. 4.)

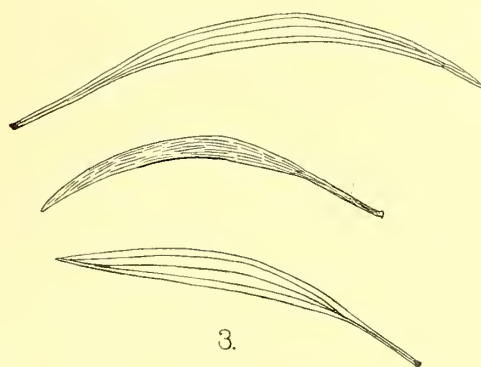
In Fig. 2 the three thoracic scales shown are false scales ; in Fig. 3 one scale is a false scale and two are true scales ; in Fig. 4 all are true scales.



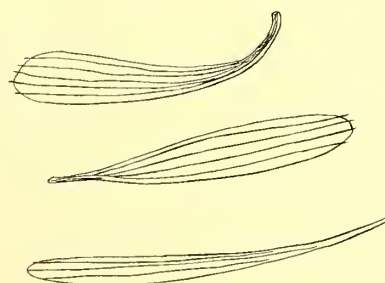
1.



2.



3.



4.

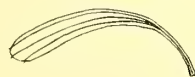




PLATE B.

EXPLANATION.

The upper half of the plate (Figs. 1 to 6) relates to

the genus NYSSORHYNCHUS.

The lower half of the plate (Figs. 7 to 11) relates to

the genus NYSSOMYZOMYIA.

Details of the upper half of the plate.—From left to right the drawings are, (1) abdomen from the dorsal aspect, (2) abdomen from the ventral aspect, (3) last segment of abdomen and genitalia, (4) thorax. Fig. 5 shows three of the abdominal scales as drawn with the aid of a camera lucida under a $\frac{1}{2}$ -inch oil immersion objective and low eyepiece. Fig. 6 shows some of the thoracic scales drawn by the same method. The three thoracic scales to the left are from *fuliginosus* and the three to the right are from *maculatus*.

Details of the lower half of the plate.—Genus *Nyssomyzomyia*. The thoracic and abdominal scale ornamentation of *rossi* is shown. Fig. 8 shows the ventral surface of the last abdominal segments. The long pointed false scales and the hair on the right of the plate are from the anterior promontory and mid region of the dorsum of the thorax; and the two true scales below the short black line (Fig. 11) are from the ventral surface of the last abdominal segment.

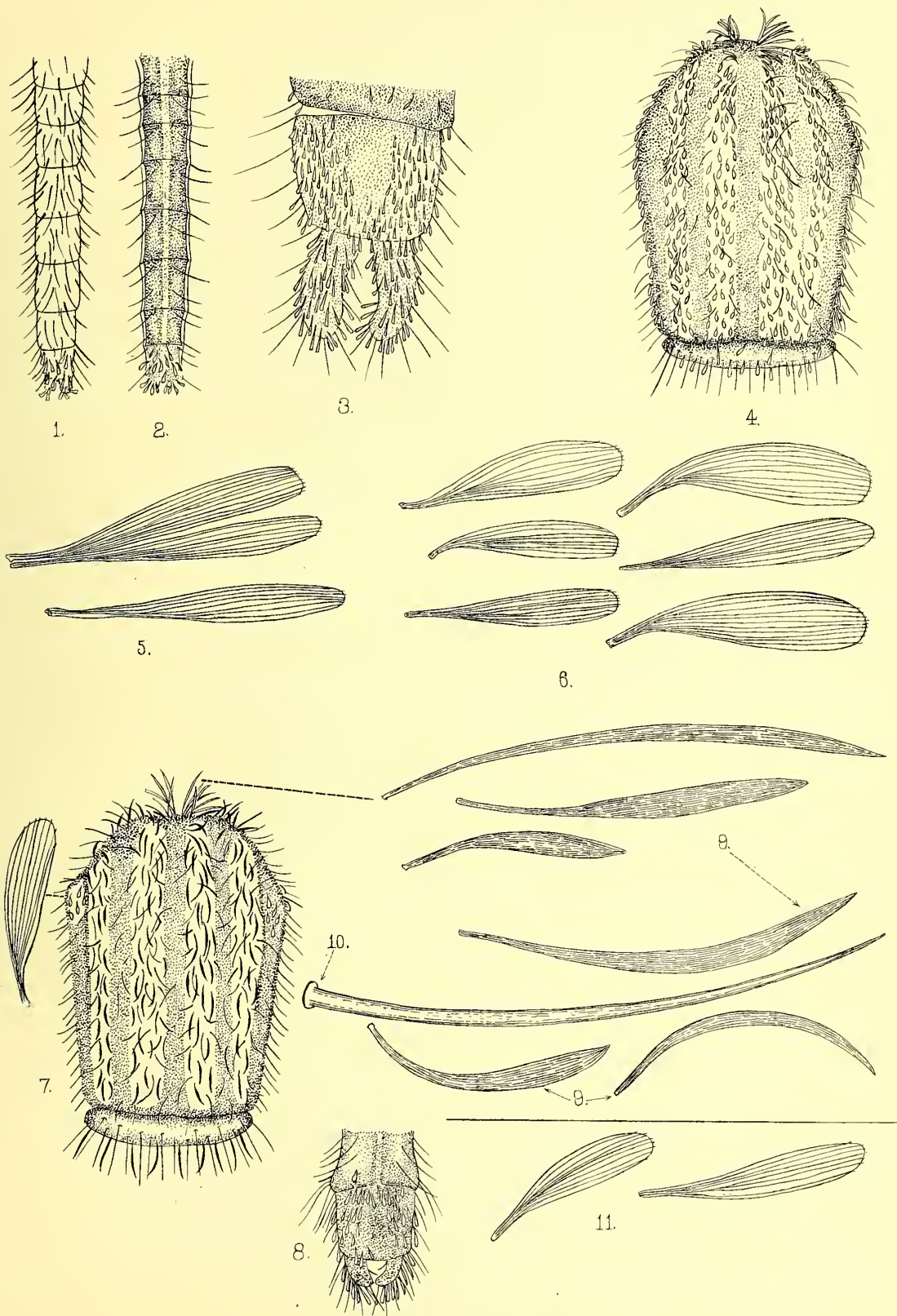




PLATE C.

EXPLANATION.

The upper half of the plate (Figs. 1 to 5) relates to
the genus NEOCELLIA.
The lower half of the plate (Figs. 6 to 16) relates to
the genus CELLIA.

In both cases the following structures are shown : (1 and 6) abdomen from the dorsal aspect, (2 and 7) abdomen from the ventral aspect, (3 and 8) abdomen from the side ; (4 and 9) abdominal scales and (5 and 10) thoracic scales. As regards the genus *Neocellia*, some of the scales (the larger ones) are from *willmori* and others (the smaller) from *stephensi*. As regards the genus *Cellia*, all the scales are from *pulcherrima*.

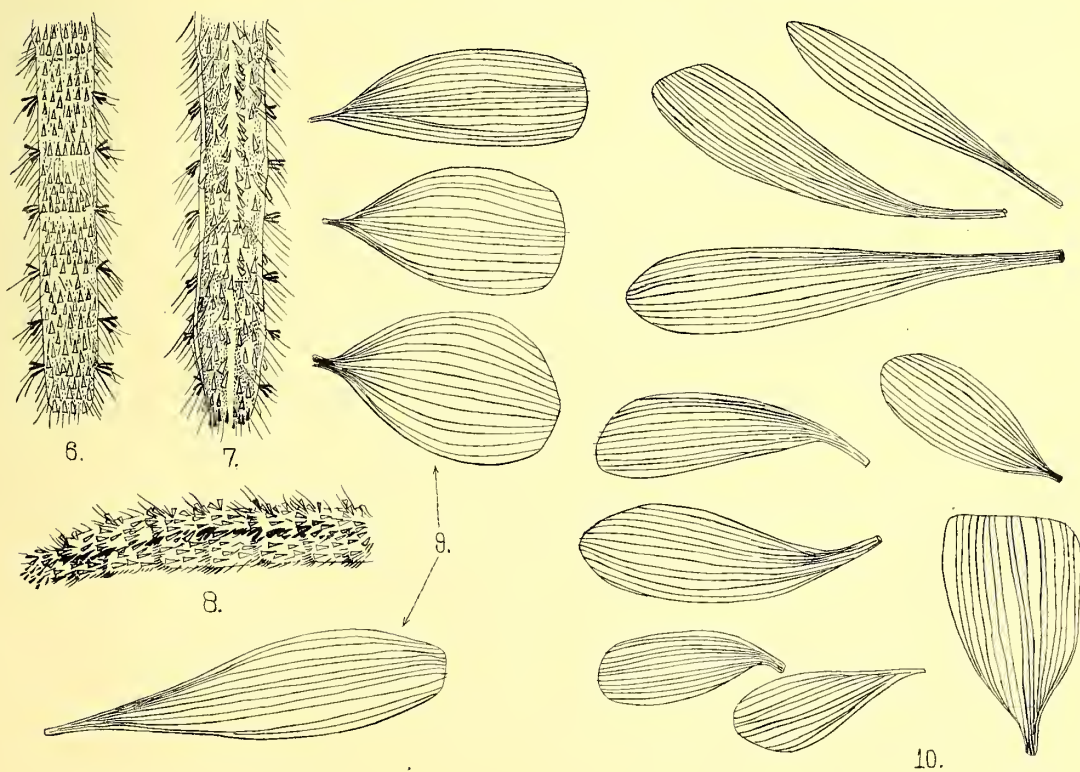
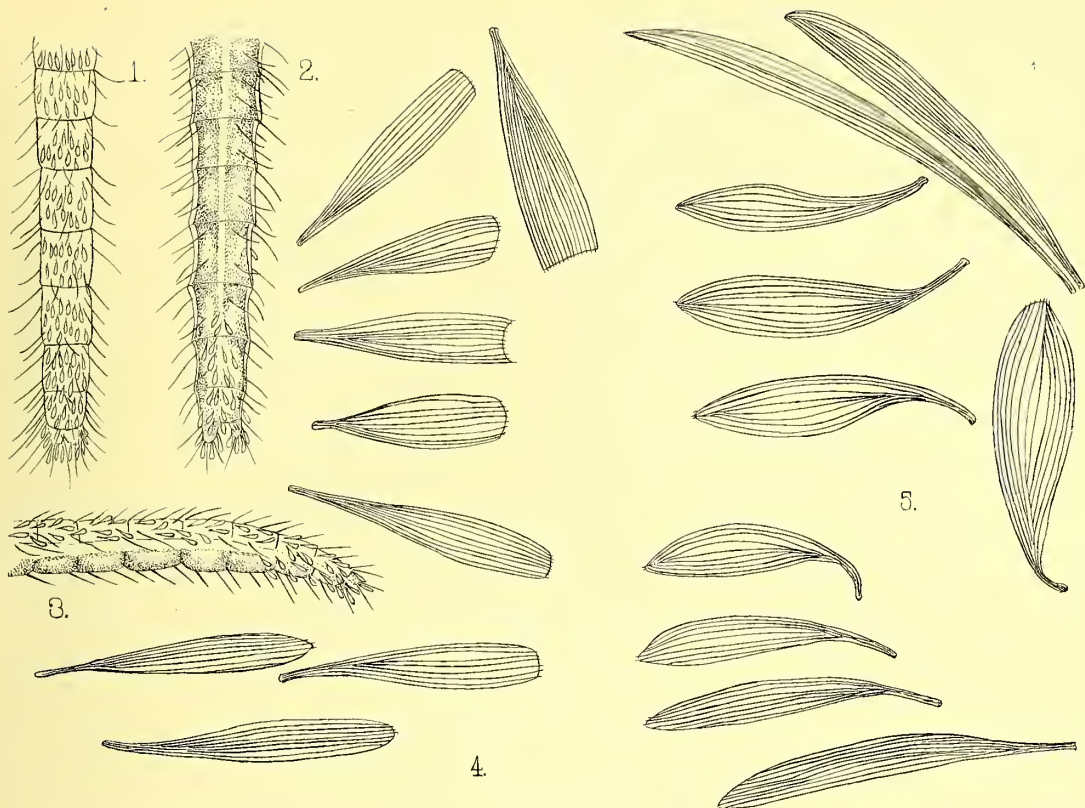




PLATE IV

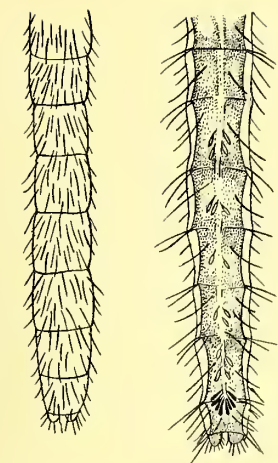
PLATE IV

The upper half of the plate (1) shows the same group of
 The lower half of the plate (2) shows the same group of
 In both cases the water-organisms of the sedimentary layer, and the
 (3) and (4) show the same group of water-organisms. The two sides of the plate
 are in 1 and 2 are from the same sedimentary layer.

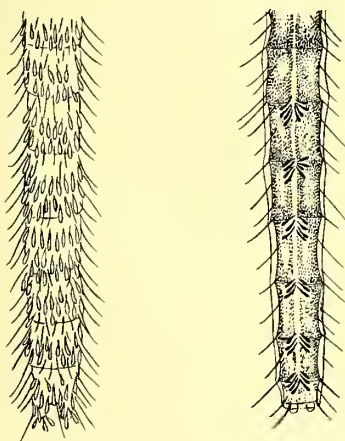
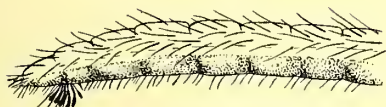
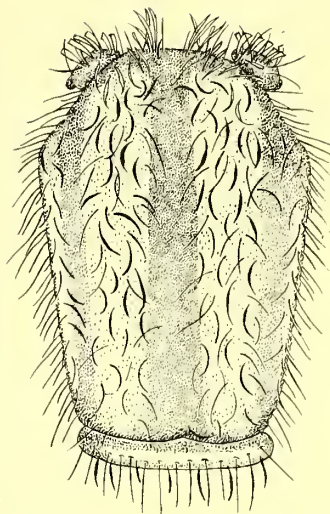
PLATE D.
EXPLANATION.

The upper half of the plate (1.) relates to the genus ... MYZORHYNCHUS.
The lower half of the plate (2.) relates to the genus ... CHRISTOPHERSIA.

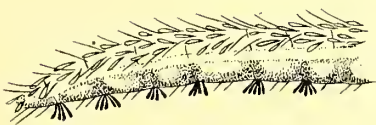
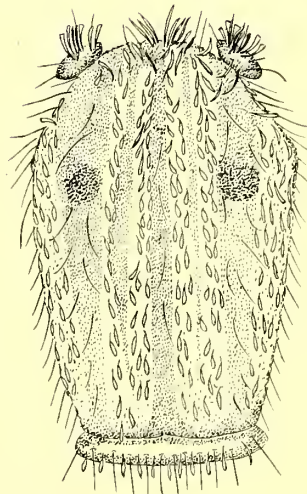
In both cases the scales ornamentation of the abdomen, thorax, and prothoracic lobes is shown. The two scales below the lateral view of the abdomen in 1. are from the ventral abdominal tuft.



1



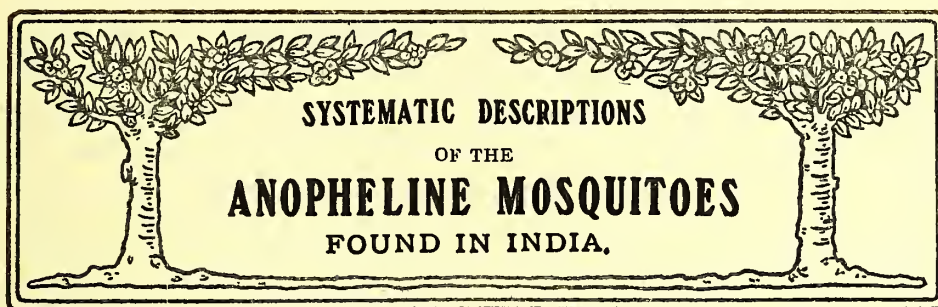
2.





PART II.





GENUS *NEOSTETHOPHELES*, *gen. nov.*

(For definition of generic characters see page 40).

NEOSTETHOPHELES AITKENI, James.

Synonym : *Anopheles aitkenii* (Theobald).

Reference :—Theobald, Monog. Culicid. Vol. III, p. 22.

Figures facing text.



THIS small mosquito with unspotted wings is the type species of the genus *Neostethopheles*. The following new description of it has been drawn up after comparing our specimens with the type examples in the Indian Museum. The determination of the specific name of those specimens was made by Mr. Theobald.

Palpi thin ; clothed with small black scales ; there is no trace of banding on them. *Proboscis* thin ; black in its whole length. *Antennæ* with rather long black hairs at the joints.

Head black. The nape, occiput and lateral areas carry dark brown *linear* (rod-shaped) upright forked scales. No broadly expanding upright forked scales of the usual anopheline type are present. The vertex carries a small bunch of short white oblongate scales, and a very few long white hairs and linear scales project forward from this area.

Thorax very dark brown ; provided with long brown hairs, but without scales of any kind. *Scutellum* with hairs only.

Metanotum bare. *Prothoracic lobes* not differing in structure from those of other anophelines. They carry hairs, but no scales.

Neostethopheles aitkeni.

Wings unspotted. The veins carry scales of the shape shown in the plate of wing scales. It is characteristic of the wings of this species that the first sub-marginal cell is almost exactly double the length of the second posterior cell. We have seen no other anophele line in which the first sub-marginal cell is so much longer than the second posterior. The mid transverse vein is external to the supernumerary and posterior transverse veins which are practically opposite each other.

Legs brown throughout. There is no trace of banding at any of the joints. The first tarsal segment of the hind leg is longer than the tibia.

Abdomen black ; with many long brown hairs, but without scales of any kind.

The specific characters of the male insect do not differ in any important respect from those of the female.

Characters of the larva.—The median frontal hairs are stout and bifurcated like the prongs of a pitchfork. The external frontal hairs are simple, short and unbranched. The palmate hairs are well developed on the 2nd to the 7th abdominal segments. The terminal filaments of the leaflets are rather short.

Localities.—Collected near Karwar (Bombay Presidency) by Dr. Cogill and on the Goa Frontier by Mr. Aitken. It occurs also in the Bengal Duars.

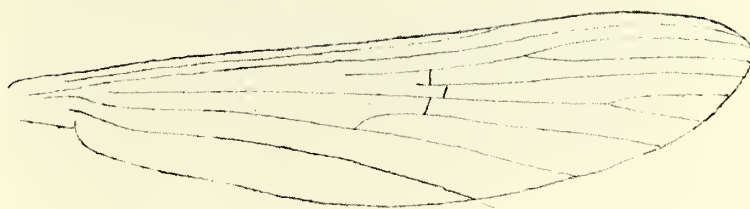
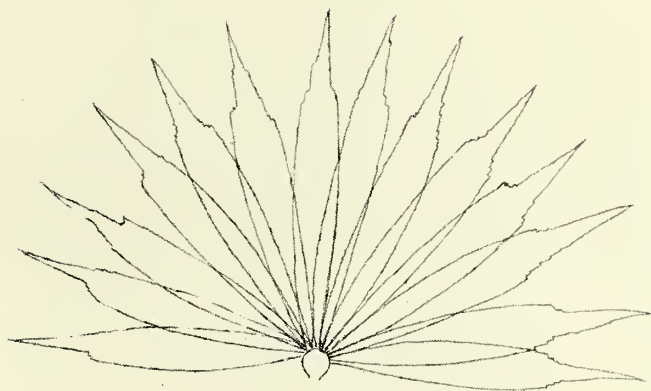
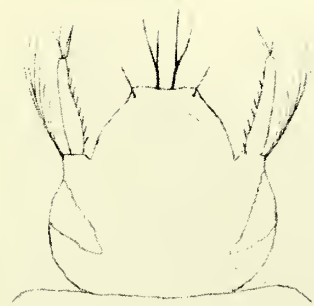
Habits.—Nothing has been published regarding the habits of the species.

Remarks.—In Vol. III of his Monograph on page 23, Mr. Theobald says that this species bears a very strong resemblance to *Anopheles bifurcatus*. We find the following to be the more important differences.

	General colouration.	Upright forked scales of head.	Thoracic ornamentation.	Wings.
<i>bifurcatus.</i>	Light fawn.	Of the usual broadly expanding type.	Hairs and very narrow sharp-pointed curved tapering scales as in the genera <i>Anopheles</i> and <i>Myzomyia</i> .	The 1st sub-marginal cell is hardly $1\frac{1}{2}$ times as long as the 2nd posterior cell.
<i>aitkeni.</i>	Black.	The upright forked scales are all of the linear type.	Only hairs are present.	The 1st sub-marginal cell is twice as long as the 2nd posterior.

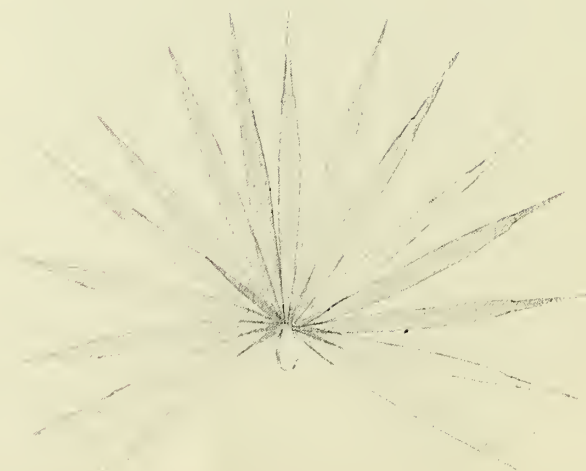
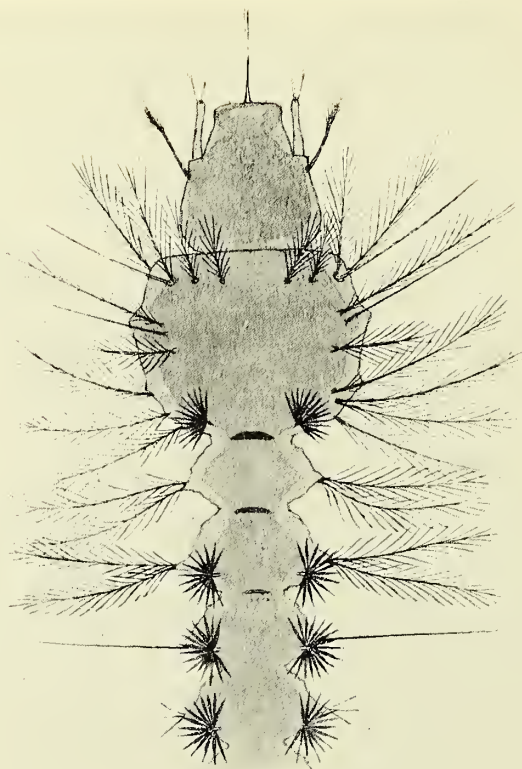
To face page 60.

PLATE VIII.



Neostethopheles aitkeni; showing the head of the larva (note the "basal hairs" external to the antennæ), a palmate hair, and the outline of the wing.





The larva of *culiciformis* ; showing the characteristic "basal hairs" external to the antenna, the absence of palmate hairs on the first abdominal segment, and the shape of the palmate hair leaflets.

Neostethopheles culiciformis.

The scale ornamentation of *bifurcatus* is similar to that of *maculipennis*, Meigen, and it therefore comes in the group or genus *Anopheles*; the scale ornamentation of *aitkeni* is so different that we have created a new group for it, namely, *Neostethopheles*.

NEOSTETHOPHELES CULICIFORMIS, James and Liston.

Synonym: *Stethomyia culiciformis* (J. & L., Theobald).

Reference:—Theobald, Vol. IV, p. 62.

Since the publication of the first edition of our book we have had no opportunity of examining this mosquito, but from our former description we have no doubt that it has on the head only the very narrow rod-shaped upright forked scales characteristic of the genus *Neostethopheles*.

A moderately large, brown anopheline.

Palpi slightly shorter than the proboscis; entirely covered with brown scales. There is no trace of banding.

Head with very narrow brown linear upright forked scales at the back and sides; on the vertex a few white oblanceolate scales. There is no distinct frontal tuft of hairs.

Thorax clothed chiefly with long brown hairs and bristles, but a few very narrow sharp-pointed tapering curved white scales may also be present. *Prothoracic lobes* with bristles but without scales. *Scutellum* with hairs only.

Wings unspotted; the veins clothed with rather broad scales. The first sub-marginal cell is longer than the second posterior cell but not (as in *aitkeni*) unusually so. The transverse veins are almost in one line. *Halteres* with a light stem and with the knob clothed with dark brown scales.

Abdomen brown, clothed with numerous fine golden and coarse brown hairs.

Legs unusually long and thin; without any bands at the joints.

In the male the claws on the fore legs have been described as single and unserrated (Dr. Cogill).

Characters of the larva.—(Figure facing text.) The frontal hairs are simple and unbranched, the median being very close together and long, the external very short. The basal hair is of peculiar structure,

Patagiamyia lindesayi.

consisting of a long stalk clothed with very few hairs and having a swollen extremity with a corona of fine hairs. The balancer hair on the third abdominal segment is simple and unbranched. Palmate hairs are present on the thorax and on all the abdominal segments except the first and last. The shape of the leaflets is shown in the figure. It will be seen from this description that the larva of *culiciformis* presents a number of distinctive characters.

Locality.—Karwar in the Bombay Presidency.

Habits.—Unknown.

Remarks.—When resting on a wall or other flat surface the attitude of this mosquito is markedly culex-like.

GENUS PATAGIAMYIA, *gen. nov.*

(For definition of generic characters see page 41.)

PATAGIAMYIA LINDESAYI, Giles.

Synonym : *Anopheles lindesayi* (Theobald, Giles, etc.)

References :—Theobald, Vol. I, p. 203 ; Brunetti, Catalogue of Indian Culicidæ.

(Coloured Plate.)

The following is a new description of this mosquito.

A large anopheline very dark brown to black in general colour.

Palpi entirely black without any bands ; slightly shorter than the proboscis ; not densely scaled. *Proboscis* black with the tip somewhat lighter. *Antennæ* light brown, with black hairs.

Head for the most part clothed with broadly expanding black upright forked scales, but on the vertex they are brilliantly white and from this area a small tuft of white hairs and linear scales projects forwards.

Thorax black. On the dorsum a large rectangular whitish area as in the coloured plate. A median and two lateral longitudinal dark lines can be made out on this area. On the anterior promontory of the thorax there is a small bunch of long narrow curved sharp-pointed white scales projecting over the neck. The remainder of the dorsum clothed chiefly with white and black hairs. *Scutellum* with bristles but no scales. *Prothoracic lobes* with a cocade of rather broad curved sharp-pointed black true scales projecting anteriorly. *Metanotum* black.

Patagiamyia lindesayi.

Wings with the veins clothed chiefly with black scales of the shape shown in the plate of wing scales. With the naked eye the single large yellowish-white spot at the apex of the wing is the most characteristic marking. Under a lens or the microscope the markings appear as shown in the coloured plate. The costa and first longitudinal vein are clothed entirely with very dark brown, almost black, scales except as the apex where they are clothed with white scales. The second long vein with dark brown scales except at the tips of its branches where the scales are yellowish-white. There is an additional white spot on the posterior branch near its termination. The third long vein has a patch of white scales near its beginning and another at its termination. The fourth long vein is dark scaled except for a white spot on each of its branches. On the fifth vein there is a white patch at the bifurcation and there are two white scaled areas on the anterior branch; the sixth has a white patch at its termination. The wing fringe has faint white patches opposite the terminations of the long veins. The superior transverse vein is nearly in line with the mid transverse vein; the lowest transverse vein is considerably internal to them. The first submarginal cell is considerably longer than the second posterior cell *Halteres* with black knob.

Legs black scaled almost throughout. The coxæ and upper ends of the femora are light coloured. The characteristic marking is a long pure white band on the middle third of the femora in the hind legs. There may be very small white bands at the distal ends of the femora and tibiæ in all the legs, but they are not present at any other joints.

Abdomen black, without scales of any kind, but with many long hairs.

The markings of the male insect do not differ in any important respect from those of the female.

Characters of the larva.—The antennæ carry a small branched hair. The frontal hairs are simple and unbranched. There are no thoracic palmate hairs.

Localities.—Bakloh (6,000 feet), Naini Tal (6,500 feet), Reneghat (4,000 feet), Simla (7,000 feet), Murree (7,000 feet), Tret (4,600 feet).

Habits.—During the rains adults of this species have been caught in houses in Simla. They feed readily on human beings.

Patagiamyia gigas.

PATAGIAMYIA LINDESAYI, var. MACULATA, Theobald.

Reference.—Records of the Indian Museum, Vol. IV, No. 1, 1910.

The following is Mr. Theobald's account of this variety: "The wings have a dense black spot of scales at the base of the long vein, a dense black spot of scales at the cross-veins, another at the base of the first fork-cell, a smaller one at the base of the second fork-cell and the outer edge of the costa, the first long vein and the base of the branches of the first fork-cell all very dark. There are no pale spots on the wing fringe."

Locality.—Kurseong, 5,000 feet (5-7-08).

Remarks.—In many of the specimens of *lindesayi* collected in the Punjab hills the wing scales are denser and blacker at the areas specified by Mr. Theobald than at other parts of the veins.

PATAGIAMYIA GIGAS, Giles.

Synonyms: *Anopheles gigas* (Theobald, Giles).

Myzomyia gigas (Blanchard).

References.—*Entomological Monthly Magazine*, 1901, p. 196; Theobald, Monog. Culicid, Vol. II, p. 308, Vol. IV, p. 31; Giles, Revision of the Anophelinæ, p. 19; Blanchard, *Les Moustiques*, p. 184.

The published descriptions of this species are very inadequate and we have experienced great difficulty in obtaining a specimen of it. We believe that its distribution is confined entirely to hill stations 5,000 feet or more above sea-level and that records of its having been collected in certain stations in the plains (for example Deesa, *vide* Theobald, Vol. IV, page 31) are not to be relied upon. Quite recently Major Cornwall, I.M.S., has kindly sent to one of us an authentic specimen from Coonoor—the hill station in which the species was first found—and on this specimen the following new description has been drawn up.

A large very dark brown species.

Palpi.—The palpi are chiefly black scaled, but the palpi of the specimen before us are too rubbed to enable us to say whether there are any white bands or not. It is certain, however, that the tips are black-scaled. Giles in his "Revision of the Anophelinæ," page 19, says "palpi unbanded." Theobald (Vol. II, page 308) merely

Patagiamyia gigas.

describes the palpi as being "long with deep brown scales rather thin, not quite as long as the proboscis."

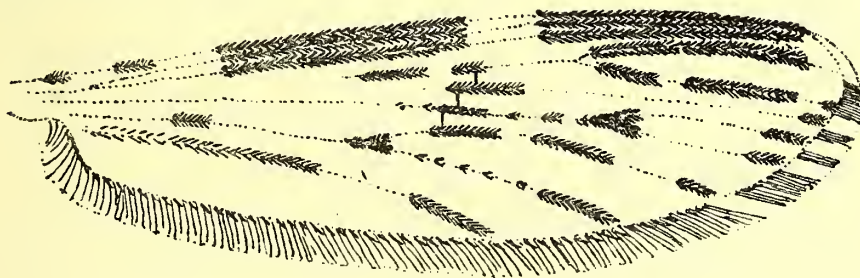
Proboscis black-scaled, lighter at the tip. *Antennæ* light brown, with white hairs.

Head with broadly expanding black upright forked scales behind and at the sides; brilliantly white ones in front. On the vertex a number of brilliant white oblanceolate scales and a good many very long linear white scales and some hairs projecting forwards.

Thorax chocolate coloured with a large rectangular whitish area on the dorsum as in *lindesayi*. The anterior promontory provided with a small bunch of white scales with acuminate (very sharp-pointed, tapering) apices and bases. The bunch projects over the neck. The remainder of the dorsum clothed with narrower curved almost acicular scales.

Prothoracic lobes with a cocade of oblanceolate scales projecting anteriorly. *Scutellum* with hairs and a few very narrow sharp pointed curved scales like those on the dorsum of the thorax. *Metanotum* bare. *Halteres* with the knob black-scaled.

Wings with the veins clothed with large scales mostly of the shape shown in the plate of wing scales. The black and white scales form spots arranged as in the figure below. With the naked eye the costa appears white in its inner fourth, then comes a long black spot, then a clear white area, then a second long black area, and finally a very small white spot.



Wing of *gigas*.

Under the microscope the following areas of black and white scales are seen. The costa has two small black spots near the base and two very long black areas. The first longitudinal vein has only two long black areas corresponding to those on the costa. The second longi-

Patagiamyia simlensis.

tudinal vein has two black spots on its stem ; the anterior branch is black-scaled in nearly its whole length, but there is a white spot at the apex ; the posterior branch is black-scaled except for a white spot about its middle and another at its apex. The third longitudinal vein has one or two black spots at its beginning and a black spot near its termination ; otherwise it is white-scaled. The fourth longitudinal vein has several small black spots about the middle of its stem and it is black scaled where it divides ; each branch has a black spot near its termination. The fifth vein has a prominent black spot on its stem : the anterior branch has three black-scaled areas and the posterior is black-scaled in nearly its whole length. The sixth vein is chiefly black-scaled but has a white area near its middle. The wing fringe has white patches opposite the terminations of the long veins except as regards the posterior branches of the second and fifth veins and the sixth vein.

Legs dark brown. The coxæ and trochanters are white and there are pale bands extending equally on both sides of each joint. The bands are most distinct at the tarsal joints of the hind legs.

Abdomen dark brown, clothed with golden brown hairs. No scales are present.

We have not seen a specimen of the male insect. Mr. Theobald says that the apices of the male palpi are pale and that each has a narrow pale band towards the base.

The characters of the larva are not known.

Locality—Coonoor, Nilgherri Hills (6,000 feet), Southern India.

Habits.—Unknown.

PATAGIAMYIA SIMLENSIS, James.

(*nov. sp.*)

This anopheline, which is not uncommon at a height of between 7,000 and 8,000 feet above sea-level in the hills near Simla, bears a close resemblance to *gigas*, but it is distinctly a smaller species and differs in that the palpi, though black tipped, have three clear white bands. In scale and hair ornamentation, however, and in wing markings the mosquito is so like the only specimen of *gigas* examined by us that if Colonel Giles had not definitely described the palpi of *gigas* as being unbanded (and Mr. Theobald is evidently of the same opinion), we

Patagiamyia simlensis.

should not have placed the mosquito in higher than variety rank. Simla is very many miles from Coonoor and it is interesting not only that in the hills of the Punjab and of Madras the anopheline fauna should be peculiar, but also that in two hill districts so far apart such similar species should occur without being present in intermediate places.

A moderately large very dark brown species.

Palpi slightly shorter than the proboscis, not densely scaled; the tips black scaled; three narrow, but distinct, clear white bands on each palp. *Proboscis* straight, black scaled in its whole length. *Antennæ* dark brown, and with unobscured white hairs at the joints.

Head with broadly expanding very black upright forked scales covering the back and sides and with a small patch of brilliantly white upright forked and oblong scales on the vertex from which area also a bunch of white hairs and linear scales projects forwards.

Thorax with the usual frosty white oblong rectangular area on the dorsum marked with indistinct black lines. The side areas of the dorsum dark chocolate brown to almost black. The lateral surfaces of the thorax lighter coloured with a few white hairs. On the anterior promontory of the dorsum a bunch of quite broad very sharply pointed curved scales projecting a little over the neck. Further back the dorsum is clothed with much narrower curved very sharply pointed white scales and with white hairs.

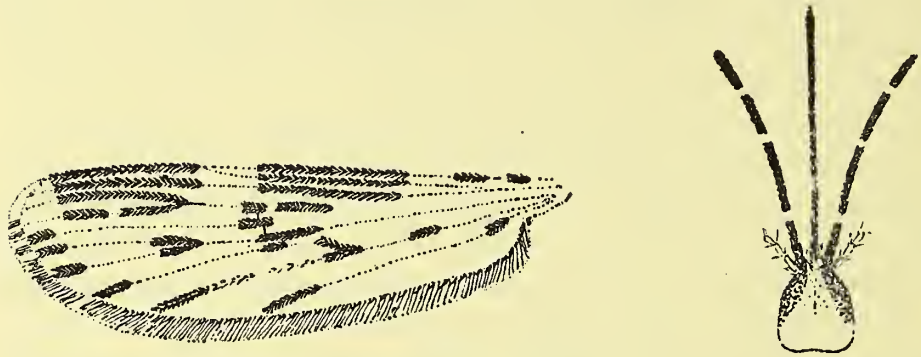
Prothoracic lobes with a coarseness of oblong scales projecting anteriorly. *Scutellum* light fawn; with hairs and a few narrow sharp-pointed curved scales like those on the posterior half of the dorsum. *Metanotum* dark chocolate coloured, nude. *Halteres* with the stem very light coloured and the knob clothed with black scales.

Wings with the veins clothed with oblong elliptical scales of the same shape as those on the wing veins of *gigas*. Length of wings 4.5 mm. Length of first submarginal cell : length of second posterior cell : : 1.33 : 1. With the naked eye the arrangement of the spots on the wings appears almost exactly as in *gigas*. Under the microscope their arrangement is seen to be as in the figure below. It will be noted that the markings on the posterior branch of the second longitudinal vein, the stem of the fourth vein, the anterior branch of the fifth vein, and the sixth vein differ from those on the same veins in *gigas*.

Legs dark brown. The coxæ, trochanters, and upper ends of the femora of each leg are very distinctly yellowish-white. In the fore

Patagiamyia simlensis.

legs there are yellowish bands at the joints between the femur and tibia, the tibia and first tarsal segment and the first and second tarsal



Wing and palpi of *simlensis*.

segments. In the mid legs the markings are similar, but in addition there is a characteristic white patch near the lower end of the femur, like the white patch at the lower end of the femur of the mid leg in *fuliginosus*. This white patch is not present in *gigas*. The hind legs are very long. There is a yellowish white band at every joint of these legs.

Abdomen yellowish brown, clothed with yellowish white long hairs. No scales are present (female).

The male insect is of a more golden brown colour than the female. Some of the long hairs on the palpi are of a golden red colour. The white banding of the palpi and the banding of the joints of the legs are more distinct than in the female. The white patch at the lower end of the femur in the mid legs is very distinct. The wing markings are the same as in the female. The hairs on the abdomen are very long and of a golden yellow colour. *The basal lobes of the male genitalia carry a number of dark true scales as well as hairs.* The insect therefore provides one of the examples showing that classification based on scale ornamentation sometimes breaks down when an attempt is made to apply it to both males and females. *The scale ornamentation of male anophelines is sometimes different from that of female anophelines.* It must therefore be kept in mind that our classification described in Chapter III applies to the female insects only. The claspers present no peculiarity of specific importance.

Characters of the larva.—The antennæ carry a small branched hair like that on the antennæ of the larva of *lindesayi*. The median

Adverse natural conditions.

and external frontal hairs are simple and unbranched. Palmate hairs are present on only the 3rd to the 7th segments of the abdomen ; their leaflets are sharp pointed and moderately short.

Locality.—Mahasu near Simla at a height of 8,000 feet above sea-level (August). It also occurs at Kathlighat in Garhwal (6,000 feet) (collected by A. D. Imms) and at Murree (collected by Major F. Smith, R.A.M.C.)

Habits.—The adults have not been found in houses. The larvæ are to be sought for in the permanent *kutchas* tanks made in hill districts for collecting water during the rains. Even in those tanks or ponds they are difficult to collect because they remain as a rule in the middle (not at the edges) of the pond. It is necessary to wade a few yards into the pond and then stand still and watch to see if any larvæ come to the surface. If one is not carrying a net a small wide test tube or mosquito tube tied (with a handkerchief) transversely across the end of a walking stick forms a very efficient catcher. One of us has found the larvæ in a forest pool more than a mile distant from any house. The female insects kept in captivity will bite and suck blood. Nothing is known of the power of flight of this species or of the method by which it tides over the very severe winter in the locality where it occurs. Usually for four months of the year Mahasu lies under snow, there is no running water during that period and all standing water is thickly frozen over. Anyone who realises the adverse natural conditions in which this species thrives and multiplies will doubtless come to the conclusion that in places where the conditions of mosquito life are less hard even the best laid plans with the object of exterminating a species of anopheline mosquito must be very ineffective.

GENUS MYZOMYIA, Blanchard.

[For definition of generic characters see page 40.]

MYZOMYIA CULICIFACIES, Giles.

Coloured plate and plates facing text.

References :—Theobald, Vol. VIII, p. 39, Vol. IV, p. 51 ; Liston, *Ind. Med. Gazette*, Dec. 1901.

A moderately small, dark-coloured mosquito very widely distributed in India.

Myzomyia culicifacies.

Palpi with three small yellow bands one of which includes the tip. They are of almost equal size and the middle band is a little nearer to the terminal band than to the basal one.

Proboscis brown, with a lighter coloured tip. *Antennæ* with short brown hairs.

Head chiefly clothed with upright forked scales of the usual broadly expanding type, some dark brown, some white. On the vertex there are a few small oblong white scales and a small frontal bunch of white hairs projects anteriorly.

Thorax.—The dorsum yellowish brown, much darker on each side of the median rectangular area and with a dark median line. On the anterior promontory from each side of the mid line a group of curved, sharp-pointed tapering scales projects over the neck. The remainder of the dorsum is clothed with golden brown narrower scales (very thin, sharp-pointed, curved tapering) and with hairs. *Prothoracic lobes* with hairs, but no scales. *Scutellum* with long bristles and a few very thin curved scales like those on the dorsum. *Metanotum* very dark-coloured.

Wings with the veins carrying scales mostly shaped as in the plates of wing scales. Under a weak hand-lens the costa shows five dark-scaled areas. Under a microscope the markings appear as follow: The costa has five very dark brown-scaled areas separated by white spots. The first dark area at the beginning of the costa is much smaller than the others. The first longitudinal vein also has five dark-scaled areas, corresponding to those on the costa. The second long vein is dark-scaled except for a tiny group of white scales at its origin, another at the cross vein and a third larger patch at its bifurcation. The third long vein has a white spot at its origin; in the remainder of its length it is dark-scaled. The fourth long vein is dark-scaled except for a white-scaled interruption near its origin, another at its junction with the cross veins and a third at its bifurcation. There are also a few white scales at the termination of the posterior branch. The fifth long vein is dark-scaled except for one white interruption on its stem and one on each branch. The sixth vein has one rather long white-scaled area. The wing fringe is white-scaled at the termination of the costa and first longitudinal vein, also at the terminations of the posterior branch of the fourth longitudinal and the anterior branch of the fifth longitudinal vein.

FIG. 1.

FIG. 2.



A.

B.



B.



C.



C.



Fig. 1.—The larva of *Culicifacies*. Fig. 2.—The larva of *Lixophaga*. Fig. B shows the long "posterior hair" of the right side.



Myzomyia culicifacies.

The relative positions of the transverse veins vary considerably but the most frequent arrangement is that shown in the coloured plate. The relative lengths of the first submarginal and second posterior cells are usually as 1.4 : 1, the first submarginal being invariably less than half again as long as the second posterior. *Halteres* with light stem and some light-coloured scales on the dark brown knob.

Legs dark brown throughout, but always with a tiny spot of yellow scales at the apical end of the tibia and occasionally with tiny spots at some of the other joints.

Abdomen dark brown, clothed with yellowish brown hairs, but without scales of any kind.

The male insect is usually lighter coloured than the female. The palpi are considerably swollen at their ends and the white banding on them is very indistinct. The male genitalia do not present any marked peculiarity.

Characters of the larva.—The median and external frontal hairs are simple and unbranched. There is a pair of palmate hairs on the thorax as well as on the abdominal segments. The terminal filament of each leaflet is longer than in the palmate hairs of *listoni* and *jeyporiensis*.

Localities.—The Punjab (Lahore, Ferozepore, Delhi, Amritsar, etc.), Bengal (Rajmahal), the United Provinces (Lucknow), Bombay (Bombay, Goa), Madras (Madras, Ennur, Armagaon, the Jeypore State, Secunderabad, Aurangabad, etc.), the Central Provinces (Nagpur), the Berars (Ellichpur), Burma (Mandalay).

Habits.—In the Punjab the larvæ of this species can be found in irrigation watercourses throughout the year, but adults cannot be detected in houses during the cold months from December to March. In the Deccan it can be found in houses throughout the hot and cold weather. It breeds also in rain-formed pools and in almost any natural collection of water. In the South of India its larvæ have been found in the water of rice fields, in borrow pits and in pools in the beds of rivers. It is markedly a "domestic" species and apparently feeds almost entirely on human beings. It has been repeatedly proved to be a very efficient carrier of malaria parasites in nature and is perhaps the species most commonly responsible for the spread of the disease in India. The adults are rather difficult to collect in houses as they hide very suc-

A new variety.

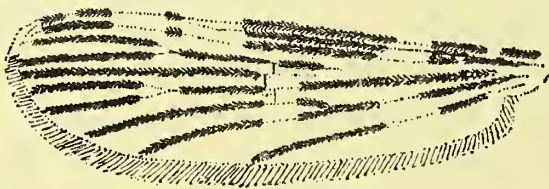
cessfully in the darker corners ; their attitude when resting on a wall or roof is *culex*-like.

Remarks.—The species is closely allied to the African species *Myzomyia funesta*. The Indian species that most closely resembles it is *listoni*, but the differences are quite definite ; they will be enumerated under the description of that species.

M. CULICIFACIES, variety PUNJABENSIS, James.

Minor variations in the markings of *culicifacies* such as an increase in the number of light-scaled interruptions on the wing fringe, a tendency to banding at the tarsal joints and an increased area of light scales on the third long vein of the wing are not uncommon. The following variety of which several specimens were collected by Captain Christophers in the Punjab is sufficiently different to merit separate description.

General colour darker than is usual in *culicifacies*. *Abdomen* almost black, with patches of white frostiness. *Legs* black with the tiny white spots at the ends of the tibiæ very distinct. *Palpi, head* and *thorax* not differing from the type species. Wings with the dark spots arranged as in the drawing below.



Wing of *Punjabensis*.

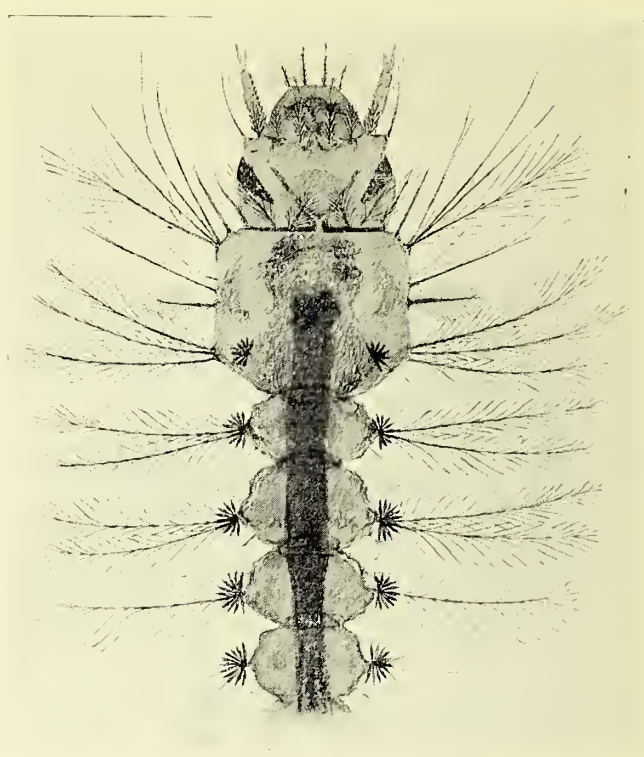
The most important difference is the almost complete absence of the fourth dark area from the costa and first long vein. In one specimen this spot is entirely absent and in all of them its small size gives the wing when examined by the naked eye or a hand-lens an appearance quite different from that of ordinary specimens of *culicifacies*. There is no light area on the wing fringe except at the termination of the costa.

FIG. 1.

FIG. 2.



A.



A.

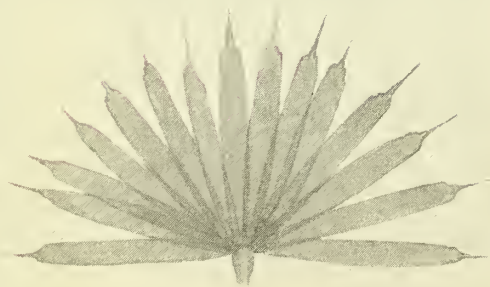
B.



B.



C.



C.

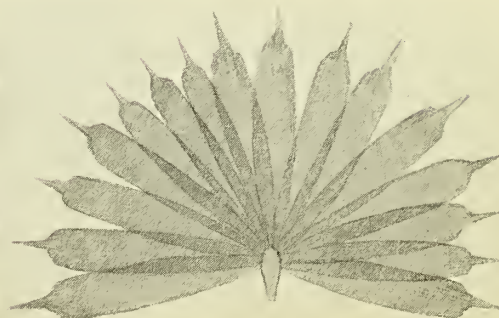


Fig. 1.—The larva of *listoni*. A.—General view; B.—Frontal hairs magnified; C.—A palmate hair magnified.
Fig. 2.—The larva of *jeyporiensis*. In figure B the “posterior hair” of the right side is seen.

Myzomyia listoni.

MYZOMYIA LISTONI, Liston.

Synonyms : *Myzomyia christophersi*, Theobald.

Myzomyia fluviatilis, James.

References :—Theobald, Vol. III, p. 27, Vol. IV, p. 51.

[Coloured plate and plates facing text.]

This species is usually small and dark-coloured.

Palpi with three white bands one of which includes the tip. The middle band is nearer to the terminal than to the basal band. *Proboscis* slightly longer than the palpi ; dark brown with a lighter tip. *Antennæ* with short whitish hairs.

Head with dark brown and white upright forked scales of the usual broadly expanding type. On the vertex there is a group of white oblongate scales and a bunch of white hairs projects forward from this area.

Thorax.—The dorsum yellowish brown with a median and two less distinct lateral longitudinal dark lines. On the anterior promontory from each side of the mid line a group of curved, sharp-pointed, tapering scales projects over the neck. The remainder of the dorsum is clothed chiefly with hairs among which some short, very thin, sharp-pointed, curved tapering scales can be seen. *Scutellum* with long bristles and a few short, very thin curved scales like those on the dorsum. *Prothoracic lobes* with hairs, but no scales. *Metanotum* very dark-coloured, with a median darker line.

Wings with the veins carrying scales mostly shaped as in the plates of wing scales. Under a weak hand-lens the costa shows four dark-scaled areas. Under a microscope the markings appear as follows :—The costa has four very dark-scaled areas separated by small white spots. The first dark area at the base of the costa corresponds in length to the first two dark areas on the costa of *culicifacies* and the fact that it is not divided into two by a white spot forms a good and constant distinction from that species. The first longitudinal vein also has four dark areas, but the first area is only half the length of the corresponding area on the costa and the second area is also a little shorter than the corresponding area on the costa. (It will be remembered that in *culicifacies* the first longitudinal vein has five dark areas.) The second long vein is dark-scaled throughout except for a tiny white area at its origin, another

Myzomyia listoni.

at the junction of the transverse veins, another at its bifurcation, and another at the termination of the anterior branch. The third longitudinal vein is white-scaled except at its origin and at its termination. (In *culicifacies* this vein is dark-scaled almost throughout.) The fourth long vein is dark-scaled except for a white-scaled area at its origin, a small spot at the junction with the transverse veins and another at its bifurcation. The fifth long vein has its stem white-scaled except for a small black spot near its origin, and some black scales at its bifurcation; the anterior branch has a small white spot where the transverse vein joins it and a tiny white spot at its termination; the posterior branch has a longer white area about its middle and one or two white scales at its termination. The sixth long vein is dark-scaled except for a small white area at its beginning and another about its middle. The wing fringe is white-scaled opposite all the longitudinal veins except the sixth. (In *culicifacies* there are only two white patches in addition to that at the apex of the costa.) The three transverse veins in the middle of the wing are arranged like steps, the lowest one being nearest the base of the wing. The relative lengths of the 1st sub-marginal and 2nd posterior cells are usually as 1.66 : 1 the first sub-marginal being invariably more than half again as long as the second posterior.

Halteres with light stem and dark scales on the knob.

Legs brown throughout and nearly always without the little patch of light scales at the apical end of the tibia which was noted to be a constant feature in *culicifacies*.

Abdomen nearly black, with yellowish white hairs but without scales of any kind.

The markings of the male insect do not differ in any important respect from those of the female. The three white bands on the palpi are distinct.

Characters of the larva.---(Plate facing text.) The frontal hairs are simple and unbranched. There is a well-developed pair of palmate hairs on the thorax. The terminal filament of each leaflet is short.

Localities.—The Berars (Ellichpur), the Central Provinces (Nagpur), the Bengal Duars, the Jeypore State, Goa, Bombay, the Hyderabad State (Aurangabad), the North Canara District, Jakot. A variety occurs at Khatala in the Punjab and typical specimens occur

Myzomyia listoni.

in the sub-montane districts of that province (collected by Major Perry, I.M.S., in 1910.) Mr. Theobald (Vol. V) states that the species has also been collected in Calcutta, and in Assam (Sylhet); also that it occurs in Ceylon and Perak.

Habits.—The species usually breeds in running streams. Captain Christophers has found its larvæ very commonly in the Duars in the mountain streams that flow during the rainy season only. The adults are strong fliers and have been found in houses more than half a mile from any breeding place. In the Duars it is the chief carrier of malaria.

Varieties—(1). As a rule the adults of this species are very small, but a large variety is not uncommon in the Duars. The dark areas on the costa in some specimens of this variety in our collection are very black and separated from one another by only very tiny white specks, so that with the naked eye the costa appears almost entirely black in its whole length. (2) The middle black area on the first longitudinal vein is frequently divided into two by a tiny white spot. (3) The third long vein of the wing is sometimes black-scaled in a considerable portion of its length. (4) In Vol. V of his Monograph (1910), Mr. Theobald describes as variety *alboapicalis*, a specimen from the Duars, in which the palpi have two very broad white bands and a third very narrow one.

Remarks.—Mr. Theobald has recently again adopted the name *christophersi* for this species but without giving any reason for doing so. It was fully described under the name *listoni* by one of us in 1901, a year before Mr. Theobald's description under the name *christophersi* appeared. In Chapter I (page 17) we have also given good reasons for the retention of the name *listoni*.

Workers in India have found considerable difficulty in differentiating some small specimens of this species from some specimens of *culicifacies*, and indeed it would seem that in a few places (*e.g.*, Bombay), the prevailing variety is almost exactly intermediate between the two species. In such cases we are inclined to regard a measurement of the relative length of the first sub-marginal and second posterior cells of the wing as the best test for identification purposes. As a rule it will be found that if the first sub-marginal cell is more than half again as long as the second posterior the specimen is *listoni*, and if the first sub-marginal is less than half again as long as the second posterior, the specimen is *culicifacies*.

Myzomyia leptomerus.

MYZOMYIA LEPTOMERES (Theobald).

References :—Theobald, Vol. III, page 38 ; Vol. V, page 25.

This mosquito was described in 1903 by Mr. Theobald from a female specimen sent by Captain Christophers from Lahore. The description indicates that in all probability it is a variety of either *listoni* or *culicifacies*. It appears to us to come nearest to the variety of *culicifacies* that we have described under the name *punjabensis*. Mr. Theobald's description is as follows :—

Head.—Dark brown, with grey upright forked scales above, black at the sides. *Antennæ* brown with pale pubescence. *Proboscis* brown with pale apex. *Palpi* black, the apex with a broad white band and with two other small white bands. *Thorax* brown, with a greyish sheen ; with pale narrow hair-like scales and golden hairs. *Scutellum* pale brown. *Metanotum* dark brown. *Abdomen* blackish, with golden hairs. *Legs* black, unbanded. *Wings* with two yellow spots on the black costa, which extend on to the first long vein ; base of the first long vein white, wing scales thin, brown except at the apices of the veins, at the base of the second fork cell and at the cross veins and on the lower branch of the fifth long vein. Apex of the wing yellow with a small black spot. Fringe with pale areas where the veins join the border. On one wing there was an additional costal spot. *Halteres* with pale stem and fuscous knob.

Genus ANOPHELES (Meigen).

(For description of generic characters, see page 40.)

ANOPHELES BARIANENSIS (James).

(*nov. sp.*)

A moderately large greyish-black species with unspotted wings.

Palpi thin ; as long as the proboscis ; entirely black-scaled and without any bands. *Proboscis* black, with yellowish tip. *Antennæ* black, but speckled with greyish-white patches ; hairs black.

Head black, with greyish white patches on the denuded areas. The nape and occiput clothed with black broadly expanding upright forked scales. The vertex with a thick patch of unusually broad

Anopheles barianensis.

curved, sharp-pointed, pure white scales and with a tuft of white hairs and linear scales projecting forward.

Thorax dark brown. The dorsum with a broad median and two lateral longitudinal stripes of a light ash-grey colour, and clothed with white hairs and white narrow, curved, sharp-pointed scales. *Scutellum* ash-grey. *Prothoracic lobes* with bristles, but without scales. *Halteres* with creamy-white stem and black knot.

Abdomen nearly black, but the dorsal surface of each segment with broad glistening areas of greyish-white. Clothed with hairs some white, some black.

Wings unspotted. The wing scales rather large, of about the same size and shape as those of *maculipennis*, Meigen. The costa darker than the other veins. The first fork cell begins a little internal to the beginning of the second fork cell and is longer than that cell, but not unusually so. The supernumerary and mid-cross veins are in a line; the posterior is considerably internal to them.

Legs light brown, clothed with black scales, but the coxæ and trochanters are pure white. On the femora and tibiæ the black scales are scanty and the parts which are bare of scales are light yellow. There is no band at any joint of the legs.

Locality.—Barian in the Murree hills, Punjab (7,000 feet). Two adults caught by Assistant Surgeon J. L. Wredden. Forwarded by Major F. Smith, R.A.M.C. (14th October 1910.)

ANOPHELES IMMACULATUS (Theobald and James).

References:—James, "Malaria in India," 1902, p. 45; Theobald, *Monog. Culicid.*, Vol. III, 1903, p. 23.

Since the publication of the first edition of this book we have had no opportunity of seeing a specimen of this mosquito. The chief part of the following description is extracted from Vol. III of Mr. Theobald's monograph.

Palpi with three whitish bands—a very broad apical one extending over nearly the outer half of each palpi, and two very narrow basal ones.

"*Head* dark brown, with grey upright-forked scales in front, ochraceous and darker ones behind, while narrow-curved scales in front form a more or less projecting mass, beneath which arises a tuft

Anopheles immaculatus.

of long white hair-like scales. *Antennæ* brown, the basal joint bright testaceous, the next few joints with pale scales. *Proboscis* about the same length as the palpi, ochraceous brown with a paler tip.

Thorax ashy-brown with slaty reflections and darker longitudinal lines, one being median. The dorsum clothed with pale golden, hair-like curved scales, a tuft of pale scales projecting over the head in front. *Scutellum* with narrow-curved hair-like, pale golden scales, and brown border bristles. *Metanotum* deep brown.

Abdomen deep brown to black, with golden hairs, which are very dense on the apical segments.

Legs ochraceous with brown scales, scantily set on the femora, so that they appear dull ochraceous; the tarsi are darker, especially on the hind legs, which have the apices of the joints banded with ochraceous; to some extent this banding may be seen in the fore and mid legs; unguis equal, simple, deep brown, large for an *Anopheles*.

Wings unspotted, with yellowish veins and pallid scales; fork-cells rather short, the first sub-marginal longer and narrower than the second posterior cell, their bases nearly level, the stems longer than the cells; supernumerary and mid-cross veins apparently in one line, the posterior cross-vein about three times its own length behind the mid-cross vein."

The male insect has not been described.

The larva has not been described.

Locality.—Ennur, a small village on the East coast about ten miles from Madras. Collected by Dr. Stephens.

Habits.—Unknown.

Remarks.—This unspotted winged anopheline bears only a superficial resemblance to *aitkeni* and *culiciformis*, but it closely resembles *barianensis*. The markings of the palpi and legs in *immaculatus* serve to distinguish the two species.

ANOPHELES TURKHUDI (Liston).

(Coloured plate and plates in the text.)

References :—Liston, *Ind. Med. Gaz.*, Dec. 1901; Theobald, Vol. III, p. 48.

A large greenish brown mosquito with black tips to the palpi.

Palpi as long as the proboscis; with black tips and three narrow white bands of equal width.

Anopheles turkhudi.

Head chiefly clothed with broadly expanding upright forked scales, very dark brown at the back and sides, white at the top and front of the head. On the vertex a bunch of sharp-pointed narrow elliptical white scales and a frontal tuft of white hairs projecting anteriorly.

Thorax brown ; on the dorsum a median rectangular area of lighter colour than at the sides. On the anterior promontory on each side of the mid line a bunch of white, sharp-pointed, curved scales projects over the neck. The remainder of the dorsum clothed chiefly with rather shorter, white, curved, sharp-pointed, tapering, narrow scales. The scales are of the same type, but longer and wider than those on the thorax of *culicifacies* and *listoni*. They are arranged so as to show a median and two less distinct dark longitudinal markings. *Scutellum* with long bristles and a few curved scales like those on the dorsum. *Metanotum* bare. *Prothoracic lobes* with hairs but without scales. *Halteres* with pale stem and dark brown knob.

Wings with rather broad scales as in the plate of wing scales. With a weak hand-lens the costa shows six black-scaled areas, the first two being near the origin and not always distinctly separated from each other. Under a microscope the markings are as shown in the coloured plate. The costa has six black areas separated by white spots. The first longitudinal has five black areas, the third of which, corresponding to the middle black area on the costa, is divided into two by a white spot. The second longitudinal is white-scaled at its origin, at the point where the transverse vein joins it, at its bifurcation and at the middle and termination of the anterior branch. The third longitudinal has a small white area at its origin and a long one in its middle third. The fourth has a white patch at the junction of the transverse veins and at its bifurcation, elsewhere it is black-scaled. The fifth has two white areas on its stem and one on each of the branches. The sixth has one white area about its middle. The wing fringe has white patches opposite the terminations of all the longitudinal veins except the sixth. The relative positions of the transverse veins vary considerably. The first sub-marginal and second posterior cells are long.

Legs very long ; dark brown, with a patch of yellow scales at the lower end of the femur and tibia in all the legs and sometimes with tiny yellow spots at some of the tarsal joints.

Anopheles turkhudi.

Abdomen olive-green ; clothed with long golden brown and whitish hairs, but without scales of any kind.

In the *male* the palpi are shorter than the proboscis. The terminal segments are much swollen and clothed with dark brown blunt-ended scales, the tips being black as in the female. The two terminal segments of the antennæ are rather longer than is usual in male anophelines of most species. The wings are very light-coloured and the black-scaled areas much less distinct than in the female. The male claspers have usually been described as being very peculiar and Blanchard (page 182) has a quite fanciful drawing of them. They terminate rather more abruptly than in some other species, but the difference is not sufficiently marked to be noteworthy. We place here a drawing of the end of one of the claspers.

Characters of the eggs and larvæ.—

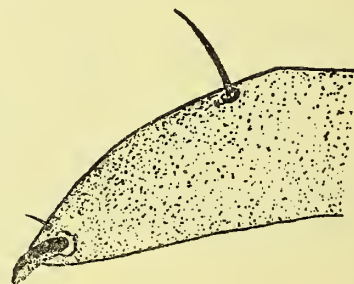
Captain Christophers has shown that the eggs of this species are very peculiar, in that the lateral floats are exceedingly rudimentary and sometimes are scarcely to be made out at all. (Fig. 8.)

The larvæ are also peculiar in having no palmate hairs on the first three abdominal segments. For this reason the larvæ rest at the surface of the water in a slanting attitude. The shape of the palmate hairs is shown in the plate. In addition to the two pairs of unbranched frontal hairs a third pair of simple hairs (the "posterior hairs") project over the mouth parts behind and between the frontal hairs.

Localities.—First found by Captain Liston at Ellichpur in the Berars. It also occurs in the Central Provinces (Nagpur), in Aurangabad (Hyderabad State), in Kashmir, and in the Punjab (collected abundantly by Captain Christophers in 1910).

Habits.—In the Punjab this species has been found to breed abundantly in the pools that remain in the beds of rivers during the rains. It has been proved that under experimental conditions the parasites of human malaria develop in this species, but it has not yet been found infected in nature.

Remarks.—The other Indian species with black-tipped palpi and three white bands are (1) *Patagiamyia simlensis*; (2) *Pyreto-*



Pyretophorus jeyporiensis

phorus nigrifasciatus; (3) *Nyssorhynchus fuliginosus* variety *nagpori*; (4) *Neocellia indica*. The absence of a cocade of scales on the prothoracic lobes of *turkhudi* and the quite different wing markings easily enable it to be distinguished from *simlensis*, and the absence of white hind tarsi distinguishes it from *nagpori*. We have not seen a specimen of *Pyretophorus nigrifasciatus*, but from the description given by Mr. Theobald in Vol. IV of his monograph, we must suppose that it is remarkably like *turkhudi*. So far as colour markings are concerned, the only differences (and these are slight and of little value) relate to the markings on the branches of the second, fourth, and fifth longitudinal veins of the wing. We must rely therefore on the statement that *nigrifasciatus* belongs to the genus *Pyretophorus*, while *turkhudi* belongs to the genus *Myzomyia*. In our view, this means that the thoracic scales of *nigrifasciatus* are rather short, quite broad, and some of them blunt-ended. The thoracic scales of *turkhudi*, as already explained, are long, sharp-pointed and curved, and although they are distinctly broader than the scales on *culicifacies* and *listoni*, and quite sufficiently broad for it to be seen at once that they are true scales, they are very narrow in their whole length. We shall for the present assume that in the two mosquitoes the difference in the character of the thoracic scales that has just been mentioned is distinct, and shall therefore regard them as separate species. We shall, however, be glad to receive specimens of *nigrifasciatus* from Quetta in order that they may be compared with our type specimens of *turkhudi*. The remaining anopheline with black-tipped palpi and three white bands, namely, *Neocellia indica*, can be readily distinguished from *turkhudi* by the fact that every segment of the abdomen is clothed with scales.

Genus PYRETOPHORUS, Blanchard.

(For description of generic characters, see page 41.)

PYRETOPHORUS JEYPORIENSIS (James).

(Coloured plate and plate facing text.)

References :—James, "Malaria in India," p. 32; Theobald, Monog. Culicid, Vol. III, p. 66; Vol. IV, p. 70; Vol. V, p. 39.

A small dark mosquito having a general resemblance to *listoni*.
Palpi as long as the proboscis; rather thickly scaled at the base.

Pyretophorus jeyporiensis.

With three white bands, the outermost of which includes the tip and is broader than the others. *Proboscis* dark brown with light tip. *Antennæ* white-scaled on the basal segments and with whitish hairs.

Head with very dark brown and black upright forked scales at the back and sides and pure white ones at the top in front. On the vertex a number of white narrowly elliptical curved sharp-pointed scales and a prominent tuft of hairs and linear scales projecting forward.

Thorax with dark longitudinal lines. The dorsum clothed with elliptical, rather short, sharp-pointed, pure white scales, some of them curved. Very few of them are blunt-ended. They are considerably broader and shorter than the scales on *listoni* or *culicifacies*, and it can at once be seen that their character is that of the genus *Pyretophorus*, not of the genus *Myzomyia*. *Scutellum* with bristles and a few narrow curved scales like those on the dorsum. *Prothoracic lobes* without a tuft of scales.

Wings with the scales mostly rather longer and broader than those of *listoni* or *culicifacies*. The costa with six black areas, the two basal ones being short. The first longitudinal vein with four black areas corresponding to the four outer areas on the costa. The second long vein with two black areas on its stem and two on the anterior branch; the posterior branch chiefly black-scaled. The third long vein chiefly white-scaled, but with a black spot near its origin. The fourth with two black black-scaled areas on its stem, two on the anterior branch and one on the posterior. The fifth with a black spot on its stem and another at its bifurcation; the anterior branch with two black spots and the posterior with one. The sixth with two black spots. The wing fringe with very long scales. It is interrupted by definite white areas at the terminations of all the long veins. The relative lengths of the first sub-marginal and second posterior cells are usually as 1.6: 1. The three transverse veins in the middle of the wing are arranged like steps, the lowest being nearest to the base of the wing; it is further from the middle vein than in *listoni*.

Legs black, with minute white bands at each joint.

Abdomen dark brown to black, clothed with golden brown hairs, but without scales of any kind.

Characters of the larva (see figure). Both the median and external frontal hairs are thickly branched. There is a "posterior hair"

Pyretophorus nigrifasciatus.

behind and between the frontal hairs. The thorax carries a pair of palmate hairs.

Localities.—First found in the Jeypore State in the Madras Presidency. It occurs also in the Central Provinces (Nagpur), and in Southern India (Jakot).

Habits.—Its larvæ have been found only in streams or in flowing water on rice fields.

Remarks.—Care must be taken not to mistake this species for *listoni* or *culicifacies*. The markings on the wings are different, but it is best to rely upon the character of the thoracic scales.

PYRETOPHORUS NIGRIFASCIATUS (Theobald).

Reference :—Theobald, Monog., Vol. IV, page 65.

We have not seen a specimen of this species. The following is an abstract of Mr. Theobald's description :—

Head deep brown, with dense upright creamy-white scales in front, deep black ones behind, a tuft of long creamy-white scales projecting between the eyes. *Antennæ* brown, with a few pale scales on the basal segments. *Palpi* deep brown, rather thin, with dark apex and three white bands. *Thorax* ashy grey in the middle, deep brown at the sides, clothed with rather long and broad, flat, narrow-curved scales of a dull creamy hue, with brown chætae which become golden over the roots of the wings. *Scutellum* with similar scales to the mesonotum and brown border bristles. *Abdomen* deep shiny brown with golden and brown hairs. *Legs* brown, unbanded, with a pale spot at the apex of the hind femora and tibiæ; ungues equal and simple.

Wings.—The costa has four moderately large and two small black areas. The first longitudinal vein has four spots corresponding to the outer four on the costa. The second long vein with two dark areas on its stem and two on each branch. The third white-scaled except for a black spot at its base, and another at its apex. The fourth with dark scales on its stem, two dark areas on its upper branch and one on the lower. The fifth with one dark area on its stem, three dark areas on the upper branch, and one on the lower. The sixth with traces of two dark areas. Fringe with pale areas except at the termination of the sixth vein. The first sub-marginal cell longer and narrower

Pyretophorus nursei

than the second posterior. The supernumerary and mid cross veins in one line, the posterior nearly twice its length from the mid. *Halteres* "deep ochraceous, with slightly fuscous knob."

Length, 5.5 mm. *Locality* Peshin (Quetta.)

Observations.—"At first sight this species, which has very large wings, might be mistaken for *Myzomyia turkhudi*, but a casual examination of the thorax shows the pale curved type of scales, showing it to be a *Pyretophorus*."

Remarks.—Although Mr. Theobald has placed this species in the genus *Pyretophorus*, we are doubtful about its being distinct from *turkhudi*. In comparison with the thoracic scales of *Myzomyia listoni* and *culicifacies*, those of *turkhudi* would be rightly described as being rather broad.

PYRETOPHORUS NURSEI (Theobald).

Reference :—Theobald, Monog., Vol. IV, page 66.

This species was described by Mr. Theobald from a single specimen. We have not seen it. Mr. Theobald's description of it is so similar to his description of *nigrifasciatus* that it is unnecessary to summarize it. The specimen was regarded as a distinct species because the apical white band on each palp included the tip, so that the tip was white-scaled instead of black. The specimen was obtained by the same collector and in the same place as the specimens of *nigrifasciatus*. As we are aware that in some specimens of *fuliginosus* the tips of the palpi are black, in others white, we do not think the character is of specific importance.

Genus NYSSORHYNCHUS, Blanchard.

(For description of generic characters, see page 43.)

NYSSORHYNCHUS MACULATUS (Theobald).

Reference :—Theobald, Monog., Vol. I, page 171.

The following is a new description of this mosquito, the type species of the genus *Nyssorhynchus*.

Palpi slightly longer than the proboscis, the basal segments rather densely clothed with long dark brown scales. Each palp has

Nyssorhynchus maculatus

three white bands. The outermost band includes the tip and is separated by a very narrow black-scaled area from the next white band which is nearly equal to it in breadth. The third white band is much nearer the base and is very narrow. Sometimes there may be slight white-scaled speckling of the palpi between the middle and the basal white bands.

Proboscis dark brown, with a lighter tip. *Antennæ*.—The basal segments with a few white scales. With whitish hairs at the joints of the segments.

Head thickly clothed with upright forked scales, which are very dark brown at the back and sides and white at the top anteriorly. On the vertex a few white blunt-ended scales and a tuft of long white linear scales and hairs projecting anteriorly.

Thorax light brown, darker at the sides; clothed with hairs and quite broad creamy white scales. On the anterior promontory on each side of the mid-line a bunch of long, white, curved, sharp-pointed, narrowly elliptical scales projects over the neck. On the remainder of the dorsum the scales are mostly short and comparatively broad, some blunt-ended, some sharp-pointed. They are not so broad as in most other species of the genus *Nyssorhynchus*. *Prothoracic lobes* with hairs and bristles, but without scales. *Scutellum* with long hairs and some scales like those on the dorsum.

Halteres with light stem and dark brown knob.

Legs brown. The fore legs have the femora, tibiæ and first tarsal segments speckled with patches of white scales. The second to the fifth tarsal segments are not speckled, but there are small white bands at the joints between the first and second, second and third, and third and fourth segments. The mid legs have the same markings as the fore legs, but the bands between the second and third and third and fourth tarsal segments are less distinct and may be absent. The hind legs have the femora, tibiæ, and first tarsal segments speckled with white patches, and there is one white patch at the middle of the second tarsal segment. The apices of the femora, tibiæ, and first tarsal segments are tipped with white scales and at the joints between the second and third, third and fourth and fourth and fifth tarsal segments, there are broad white bands extending equally on both sides of the joints. The fifth tarsal segment is white in its whole length.

Nyssorhynchus maculatus.

Wings.—The costa has three tiny black spots at its beginning and then four longer black areas separated by rather long white ones. The sub-costal vein has black areas corresponding to three of the black areas on the costa. The first longitudinal vein has four black areas corresponding to those on the costa, but the second area is divided into three by two small white spots. The second long vein has two black areas on its stem and two on each branch. The third has two small black areas at its beginning and one at its termination. The fourth has two long black areas on its stem, the first of them being beneath the middle of the costa, and there are two black areas on each branch. The fifth has a single black area near its origin; the rest of its stem is white-scaled. There are three small black areas on the anterior branch and one on the posterior. The sixth has three small black areas. The wing fringe is white-scaled opposite each long vein. The three middle cross veins are arranged like steps, the lowest being nearest the base of the wing. The relative lengths of the first sub-marginal and second posterior cells are usually as 1.5 : 1.

Abdomen dark brown; the first six segments clothed with golden brown hairs but without scales, the seventh and eighth segments and the genital processes clothed with scales as well as hairs. The scales are rather long and not very broad; they are irregularly disposed on the dorsal and ventral surfaces and are not aggregated to form tufts. Sometimes the sixth segment also carries a few scales.

In the *male* the second white band on each palp is usually divided into two by a narrow black band, so that the palpi would be rightly described as having four white bands, three being broad and near the tip, the fourth narrow and much nearer the base. There are no other noteworthy differences between the markings of the male and female.

Characters of the larva.—The frontal hairs are simple and unbranched. Palmate hairs are present on the second to the seventh abdominal segments; the terminal filament of each leaflet is very short.

Localities.—The Bengal Duars, Kurseong, Jalpaiguri.

Remarks.—There has been much confusion regarding this species, and specimens of *karwari*, *willmori*, *stephensi* and *theobaldi* have frequently been mistaken for it. In Vol. V of his Monograph (synoptic table) Mr. Theobald incorrectly places it as one of the species with

N. pseudowillmori.

four white bands on the palpi. The new species described by him as *Nyssorhynchus pseudowillmori* on page 65 of Vol. V, from Meenglas (Dooars) and Jalpaiguri, is certainly nothing but a specimen of *maculatus* and has no resemblance to *willmori*.

NYSSORHYNCHUS PSEUDOWILLMORI (Theobald).

Reference :—Theobald, Monog. Culicid, Vol. V (1910), page 65.

The type of this species, which is in the Indian Museum, Calcutta, is a specimen of *maculatus*. It is evident also that Mr. Theobald's description of the species (Vol. V, page 65), is a re-description of that species. The mistake of describing well-known species under new names is not uncommon and great care has to be taken to guard against it. (See also the remarks under *dudgeonii*, *intermedia* and *nigri-fasciatus*.)

NYSSORHYNCHUS FULIGINOSUS (Giles).

Reference :—Giles, Handbook Mosq., First Ed., p. 160 ; Liston, Ind. Med. Gazette, 1901, p. 441.

(Coloured plate and plates in the text.)

An abundant and widely distributed species.

Palpi black-scaled, and with three white bands, the outermost of which includes the tip and is broad ; the other two bands are narrow. *Proboscis*, black, with white tip. *Antennæ* black with short dark hairs.

Head clothed with broadly expanding black upright forked scales at the back and sides, white ones at the top in front. On the vertex there are some white oblongate scales and a tuft of long hairs and linear scales projects forward from this area.

Thorax very dark brown to black. On the dorsum a median and two lateral lines can be indistinctly seen. The dorsal surface clothed with brilliant white rather broad, short scales, some sharp-pointed, some blunt-ended. The scales are arranged in four principal longitudinal rows with bare areas between. The scales on the anterior promontory are longer and more tapering than those on the main area of the dorsum, but they do not form so prominent a bunch as in some other species of the genus. The thorax also carries some

N. fuliginosus

white hairs. *Scutellum* with long hairs and a few scales like those on the dorsum. *Prothoracic lobes* with bristles but without scales.

Abdomen very dark brown to black. The first six segments are clothed with rather short whitish hairs but carry no scales. The seventh and eighth segments and the genital processes carry in addition to hairs a number of scales, some white, some black. The scales are disposed irregularly on the dorsal and ventral surfaces; they do not form tufts.

Wings chiefly black-scaled, with minute white spots. The costa has six long black-scaled areas separated by tiny white spots. The first longitudinal is black-scaled except for a white patch at its beginning, another at its termination and four tiny white spots in its course. Two of these spots are situated beneath the long middle black area on the costa. The second longitudinal is nearly wholly black-scaled, but there are a few white scales at its bifurcation and a few on its posterior branch. The third longitudinal has a tiny white spot near its origin, another at its termination and a rather long white area in the middle of its course. The fourth has the stem entirely black-scaled; there is a white-scaled patch at the bifurcation and a similar patch on each branch. The termination of each branch is also tipped with white scales. The fifth longitudinal has two white patches on its stem, two on the anterior branch and one on the posterior. The tips of the branches are white-scaled. The sixth has three white-scaled patches. The wing fringe is interrupted by white-scaled areas opposite all the long veins.

Legs black. In the forelegs the distal ends of the femora and tibiæ are tipped with white scales and at the distal ends of the first, second, and third tarsal segments there are narrow bands. In the mid legs the femur has a characteristic rather large oval patch of white scales near its distal end; the distal ends of the femur and tibiæ are tipped with a few white scales and at the distal ends of the first, second and third tarsal segments there are narrow white bands. In the hind legs the distal ends of the femur and tibiæ are tipped with white scales and the distal end of the first tarsal segment has a narrow white band; the distal end of the second tarsal segment has a broader white band, and the third, fourth and fifth segments are white-scaled in their whole length.

In the male insect the palpal banding varies considerably.

Varieties

Characters of the larva (see plate). The median frontal hairs are slightly branched and the external frontal hairs are much branched. There is no branched hair on the antenna, and the thorax does not carry palmate hairs.

Localities.—Calcutta and almost everywhere in the plains of Bengal. Kurseong (5,000 feet). Ferozepore, Lahore, Amritsar, Delhi and many other places in the Punjab. Madras and several places on the East Coast. Nagpur and many other places in the Central Provinces. Bombay, Goa, Ellichpur in the Berars, Quilon and other places in Southern India.

Habits.—In Calcutta, Nagpur and Ferozepore this species is common in houses. It is a strong flier. Its larvæ are usually found in shady natural ponds or tanks with grass and weed at the edges. It has been proved to be a carrier of malaria in nature. (J. R. Adie.)

N. FULIGINOSUS variety ADIEI (*nov. var.*)

Some years ago Lieutenant-Colonel Adie, I.M.S., drew our attention to an interesting variety of *fuliginosus* having four white bands on the palpi and only the last $2\frac{1}{2}$ or $2\frac{3}{4}$ hind tarsal segments white. It appears from his observations that the variety is a seasonal one; in the Punjab as winter approaches the ordinary form of *fuliginosus* is gradually replaced by this variety, and in the spring the ordinary form is again the only one found. The markings of the variety are very constant, and if breeding experiments had not shown that it is really only a variety, it would certainly be regarded as a distinct species. The following description has been drawn up from some specimens collected in 1910 by Captain Christophers.

Palpi black-scaled and with four very distinct narrow white-scaled bands, the outermost of which includes the tip.

Head and thorax as in *fuliginosus*.

Wings almost exactly as in the type except that the third longitudinal vein has no long white area in the middle of its course. There may be a tiny white spot near its origin and another at its termination, but usually it is black-scaled in its whole length.

Legs black. Fore-legs with white markings as in the type. In the mid legs the femora have the characteristic white patch near the

Varieties.

lower end as in the type. The distal ends of the femora and tibiae are tipped with a few white scales, and there are very narrow white bands at the distal ends of only the first and second tarsal segments. There are no white scales at the distal end of the third segment. In the hind legs the distal ends of the femora, tibiae and first and second tarsal segments are tipped with white scales. The third tarsal segment is black-scaled in the first third of its length; the lower two-thirds of this segment as well as the whole of the fourth and fifth segments are completely white-scaled.

Abdomen as in the type.

Localities.—Ferozepore and Amritsar in the Punjab.

N. FULIGINOSUS variety NAGPURI (James and Liston).

The following is a new description of this well-marked variety.

Palpi black-scaled and with three narrow white bands of equal breadth. The outermost band is some distance below the tip, so that the tips of the palpi are black. The base of each palp is densely scaled.

Head and *thorax* as in the type species.

Wings with the following chief differences from the type. The first longitudinal vein has a long white patch at its beginning and a tiny white spot at its termination; and there are two small white spots in the middle of its course. The second longitudinal has a white patch at its bifurcation; otherwise it is entirely black-scaled. The third has a tiny white patch at its origin and another at its termination; otherwise it is entirely black-scaled. The fourth, except for a white spot at its bifurcation, and a tiny one on the posterior branch, is black-scaled throughout. The fifth has only one white patch on the anterior branch and none on the posterior. The sixth is as in the type.

Legs light brown to black on the tarsal segments. In the fore legs the femora and tibiae are not tipped with white scales. There are white bands at the distal ends of the first, second and third tarsal segments. In the mid legs the distal ends of the first and second tarsal segments are tipped with a few white scales, but there are no white bands at any of the joints. In the hind legs the femora,

N. jamesi.

tibiæ and first and second tarsal segments are tipped with white; the first third of the third tarsal segment is black-scaled, and the lower two-thirds white-scaled, the fourth and fifth segments are white in their whole length.

Abdomen with some white scales on the seventh and eighth segments and on the abdominal processes.

Localities.—Nagpur in the Central Provinces. Anritsar and other places in the Punjab. (Collected by S. R. Christophers.)

NYSSORHYNCHUS JAMESI (Theobald).

(Coloured plate.)

A small species having a superficial resemblance to *fuliginosus*, but differing in that the femora and tibiæ are speckled with white spots.

Palpi black-scaled and with three white bands, the outermost of which includes the tip and is broader than the others. *Proboscis* black, with lighter tip. *Antennæ* with white hairs.

Head chiefly clothed with black upright forked scales, but in front there is a patch of white ones. On the vertex there are a number of white blunt-ended oblongate scales and a very small tuft of white hairs and linear scales projects forward from this area.

Thorax black. The dorsum clothed with short, broad, white scales irregularly disposed, some blunt-ended, some sharp-pointed. On the anterior promontory a few tapering sharp-pointed curved scales. *Prothoracic lobes* with hairs, but without scales. *Scutellum* with hairs and some white scales like those on the dorsum.

Wings with the black and white spots arranged as follows. The costa has six black-scaled areas, two of them being small and near the origin. The first longitudinal vein has four principal black areas corresponding to the four chief areas on the costa. Sometimes there is in addition a tiny black spot at its origin. The second large area which corresponds with the longest (middle) black area on the costa is divided into three (sometimes only two) by two tiny white spots. The second long vein has a black-scaled area on its stem, a long black area on its anterior branch and one long and one very short

N. jamesi

area on its posterior branch. The third vein has two small black areas at its beginning and one at its termination. The fourth vein is chiefly white-scaled, but there are two dark-scaled areas on its stem and two on each branch. The fifth has a small black area near its origin and is black-scaled at its bifurcation; there are two other black-scaled areas on the anterior branch and one on the posterior. The sixth has three black spots. The wing fringe has white-scaled areas opposite the ends of all the long veins. The relative lengths of the first sub-marginal and second posterior cells are usually as 1.5:1. The three cross veins in the middle of the wing are arranged in steps, the lowest being nearest the base of the wing. *Halteres* with whitish stem and black knob.

Legs light brown to nearly black on the tarsal segments. In all the legs the femora, tibiae and first tarsal segments speckled with white scales; the speckling on the first tarsal segments is slight. In the fore-legs the distal ends of the femora and tibiae are tipped with a few white scales and hairs; the first, second and third tarsal segments have broad apical bands. The first tarsal segment has a large faint yellowish white spot just above its middle. In the mid legs the markings are the same as in the fore legs. In the hind legs the femora and tibiae are tipped with white scales and the first and second tarsal segments have broad apical bands, the third, fourth and fifth segments are white in their whole length.

Abdomen black, clothed with whitish hairs on the first seven segments and with scales and hairs on the eighth segment and the genital processes. The scales are irregularly disposed as in *fuliginosus* and do not form tufts. Sometimes a few scales are present on the seventh segment.

Characters of the larva.—The median and external frontal hairs are branched. The thorax carries a pair of rudimentary palmate hairs.

Localities.—Quilon, Southern India. Calcutta and several places in Bengal. Nagpur in the Central Provinces.

Remarks.—In the first edition of this book it was stated that this species is rare; it appears to be quite common in the neighbourhood of Calcutta. It is a small mosquito with unusually small wings. None of many specimens recently examined has been larger than an average-sized *listoni*.

N. maculipalpis

NYSSORHYNCHUS MACULIPALPIS (James and Liston).
(Not Giles.)

Reference :—The First Edition of this book, page 95.

(Coloured plate and plates in the text.)

A large species which occurs in China as well as in India.

Palpi thickly black-scaled and with three white-scaled bands and patches of white scales between them. The outermost band is broad and includes the tip, the next band is separated from it by only a very narrow black band and its breadth is equal to that of the first band. The third band is narrow and at some distance from the outer bands. Between the second and third bands there are one or two patches of white scales and there may be a few white scales on the proximal side of the third band. *Proboscis* black. *Antennæ* with a few broad white scales on the first few segments and with white hairs at the joints.

Head clothed with black upright forked scales behind and at the sides, white ones on the top in front. On the vertex there are a number of oblong elliptical white scales and a tuft of white hairs and linear scales projects forward from this area.

Thorax black. The dorsum clothed with pure white, short, broad scales, some blunt-ended, some sharp-pointed and slightly curved. The scales are arranged in somewhat irregular longitudinal rows with bare spaces between. Sides of the thorax brown, without scales. *Prothoracic lobes* with black hairs and sometimes one or two white scales, but always without a tuft of scales. *Scutellum* with hairs and with some scales like those on the dorsum.

Wings large and broad; the veins chiefly clothed with black scales. The costa has four long black areas and two small ones, the latter being at the base. The first longitudinal vein has four black areas corresponding to the outer four on the costa, but the second area is divided into three by two small white spots. The second long vein has two black areas on its stem and two on each branch. The third has four black-scaled areas. The fourth has its stem almost entirely black-scaled, and there are two black-scaled areas on each branch. The fifth has two black areas on its stem, three on the anterior branch and two on the posterior. The sixth has three black-scaled areas. There are white areas on the wing fringe at the

N. maculipalpis.

ends of all the long veins. The cross veins are arranged like steps, the lowest being nearest the base of the wing. The first sub-marginal cell is long and curved. *Halteres* with pale stem and dark knob.

Legs black, much spotted with white scales. In the fore and mid legs the distal ends of the femora and tibiae are tipped with a few white scales and the distal ends of the first, second and third tarsal segments have white bands. In the hind legs the distal ends of the femora, tibiae and first tarsal segments are tipped with white, the second tarsal segment has a broad distal band and the third, fourth and fifth segments are white in their whole length.

Abdomen black with whitish sheen; the first six or seven segments clothed with white hairs. The eighth segment and the genital processes clothed rather thickly with short blunt-ended scales, some of a golden white colour, some black. The scales do not form tufts.

Characters of the larva. (Plate III).—The median and external frontal hairs are thickly branched. A pair of well-developed palmate hairs is present on the thorax.

Localities.—The Central Provinces (Nagpur). The Bombay Presidency (Karwar). The South of India (Travancore). Chitral (Drosh, 4,700 feet, collected by E. Wall).

Remarks.—It has been said that the species described by us in the first edition of this book and here re-described in more detail, is not identical with the African species described under the name *maculipalpis* by Colonel Giles. As we have not seen the type of Colonel Giles's mosquito, we must accept the opinion and have, therefore, changed our title to *maculipalpis*, James and Liston. If it is remembered that there are two anophelines named *maculipalpis*, one of which occurs in Africa (Col. Giles's species), and the other in India (our species), no confusion is likely to result. This is a better solution of the difficulty than to change the specific name of our mosquito, because the name *maculipalpis* for specimens based on our description has come into common use in India. We have examined a large number of specimens from various parts of this country and find that all correspond with our types, and we have, therefore, come to the conclusion that if Col. Giles's *maculipalpis* is not the same species as ours, it does not occur in India. We find also that the *maculipalpis* which occurs in China is our species, not Col. Giles's,

N. theobaldi.

and we conjecture, therefore, that if his species is different from ours, it is a rare mosquito.

NYSSORHYNCHUS INDIENSIS (Theobald).

In Vol. V of his Monograph Mr. Theobald says that the type of an anopheline from India named *indiensis* by him is in the British Museum. Beyond saying that its hind legs are less banded than those of Col. Giles's *maculipalpis*, he has never described this species and for this reason it cannot be accepted as valid. In all probability the specimen in the British Museum is a specimen of our *maculipalpis*.

NYSSORHYNCHUS THEOBALDI (Giles).

References :—See Theobald, Vol. V (1910), page 58.

(Coloured plate.)

Palpi with three white bands, the outermost of which includes the tip. The two outer bands are equally broad, the third is very narrow. *Proboscis* black, with lighter tip.

Antennæ with whitish hairs.

Head clothed with black upright forked scales behind and at the sides, white ones in front. On the vertex there are a few white oblong scales and a prominent bifid tuft of white hairs projects forward from this area.

Thorax black. The dorsal surface clothed with short, broad creamy-white scales arranged in longitudinal rows with bare spaces between. Some white hairs are also present. The scales on the anterior promontory are more tapering, curved and sharp-pointed. *Prothoracic lobes* without a tuft of scales. *Scutellum* with hairs and some scales like those on the thorax.

Abdomen black. The first six or seven segments clothed with long white hairs only. The eighth segment and sometimes the seventh with patches of white scales on the dorsal and ventral surfaces. The genital processes also carry scales, which are usually black. The scales on these last segments of the abdomen are irregularly disposed and do not form tufts.

Wings very black, with small white spots. The costa has six black areas, two of which at the base are very small. The first longi-

N. karwari

tudinal vein has four dark areas corresponding to the outer four on the costa, but the second area is always divided into three by two small white spots. The second long vein is for the most part white, but has two small black areas on the stem and two on each branch. The third has two small black spots at its beginning and one at its termination, otherwise it is white-scaled. The fourth has two long black areas on its stem and two small ones on each branch. The fifth has a small black spot at its origin; the anterior branch has three small black areas and the posterior one. The sixth has three black spots. The wing fringe is interrupted by light-scaled areas opposite the end of each long vein. *Halteres* with light stem and black knob.

Legs much speckled with white. In all the legs the speckling is present on the femora, tibiae and first tarsal segments. In the fore legs the distal ends of the femora, tibiae and first, second and third tarsal segments are tipped with white scales. In the mid legs the distal ends of the femora, tibiae and only the first tarsal segments are tipped with white. In the hind legs the distal ends of the femora, tibiae and first tarsal segments are tipped with white, the distal ends of the second and third tarsal segments have a white band and the fourth and fifth segments are white in their whole length.

Characters of the larva.—The frontal hairs are slightly branched or frayed. There is a pair of rudimentary palmate hairs on the thorax. The terminal leaflets of the palmate hairs are very short and blunt.

Localities.—The Berars (Ellichpur). The Central Provinces (Nagpur). The Jeypore State (Madras Presidency). Behar. Karwar (Bombay Presidency).

Habits.—The larvæ have usually been collected from streams.

NYSSORHYNCHUS KARWARI (James).

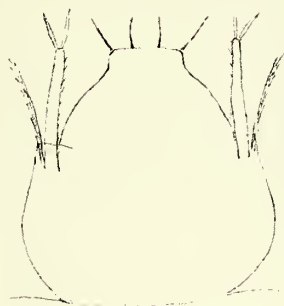
Reference :—The First Edition of this book, page 89.

(Figure facing text.)

Palpi thickly clothed with scales and having four white bands, the outermost of which includes the tip. The two terminal bands are equally broad, the other two are narrower. *Proboscis* dark brown with lighter tip. *Antennæ* black, with silvery hairs.



A. Karwari



Nyssorhynchus karwari ; showing the markings on the palpi and hind leg, and the head of the larva.



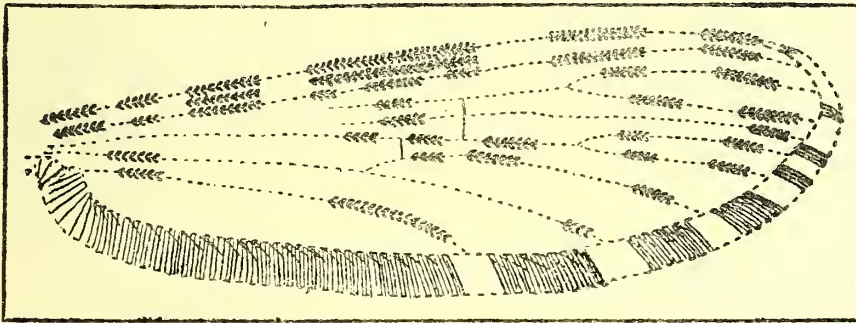
N. karwari.

Head with white upright forked scales in front, dark ones behind and at the sides. On the vertex a few white oblongate scales and a small tuft of white hairs projecting forward.

Thorax black. The dorsum clothed with snowy white, short, broad scales and on the anterior promontory some tapering ones as in other species of the genus *Nyssorhynchus*. Three longitudinal dark areas devoid of scales are present on the dorsum as well as a lateral eye-like bare spot on each side and a median bare spot posteriorly.

Prothoracic lobes without a tuft of scales. *Scutellum* with bristles and some scales like those on the thorax.

Abdomen black, thickly clothed with golden hairs. On the last two segments the hairs are densely aggregated, and on these segments there are also a number of scales, some white, some dark brown. The scales are irregularly disposed and do not form tufts.



Wings with the veins clothed with black and white scales forming dark and light areas as follows :—The costa shows four large dark-scaled areas and two small ones ; the first longitudinal vein shows dark-scaled areas exactly corresponding to those on the costa, except that the large middle area is divided into three by two small white spots. The second longitudinal vein has one dark spot on its main stem and two on each of its branches. The third longitudinal vein is white-scaled except for a small dark area at its beginning, and another at its termination. The fourth longitudinal vein has three small spots on its main stem, and two on each of its branches. The fifth longitudinal vein has one small dark area on its main stem, three on its anterior branch, and one on its posterior. The sixth longitudinal vein shows two dark-scaled areas. The wing fringe is interrupted by

Nyssomyzomyia rossi.

light-scaled areas at the terminations of all the longitudinal veins and their branches.

Legs black, not speckled. In the fore and mid legs each tarsal segment, except the fourth and fifth, has a white band at its distal end. In the hind legs the tibia and the first and second tarsal segments have white bands at their distal ends, the third and fourth segments have white bands at both their proximal and distal ends, and the fifth segment is white in its whole length.

Characters of the larva.—The median and external frontal hairs are simple and unbranched. The thorax does not carry palmate hairs.

Localities.—Karwar and Goa in the Bombay Presidency. It has also been recorded from other places in India, but we do not know whether the determinations were correct, and so do not record them.

Remarks.—The other Indian species with only the fifth hind tarsal segment white in its whole length are *Neocellia indica*, *Neocellia willmori*, and *Nyssorhynchus maculatus*. These mosquitoes have only three white bands on the palpi and the legs of all of them are much speckled.

Genus NYSSOMYZOMYIA (*nov.gen.*)

(For definition of generic characters see page 43.)

NYSSOMYZOMYIA ROSSI (Giles).

Synonyms : *Anopheles rossi* (Giles, 1899).

Myzomyia rossi (Theobald, 1903).

Pseudomyzomyia rossi (Theobald, 1907).

Myzomyia rossi (Theobald, 1910).

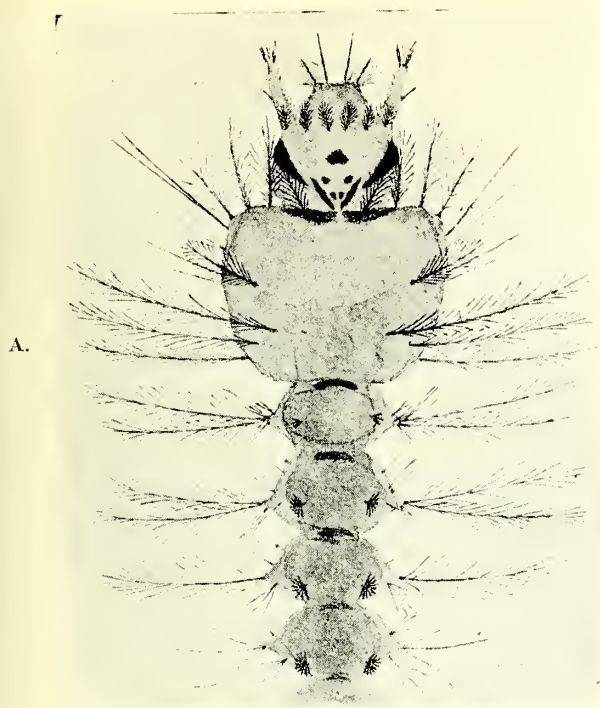
(Coloured plate and plates in the text.)

The commonest and most abundant anopheline in India. A species of medium size, the general colouration of which varies from light fawn to very dark brown.

Palpi with brown scales, rather dense and outstanding near the base. Each palp has three white-scaled bands. The outermost band is broad and includes the tip; the other two bands are narrow. *Proboscis* brown with a yellow tip. *Antennæ* brown with pale hairs.

FIG. 1.

FIG. 2.



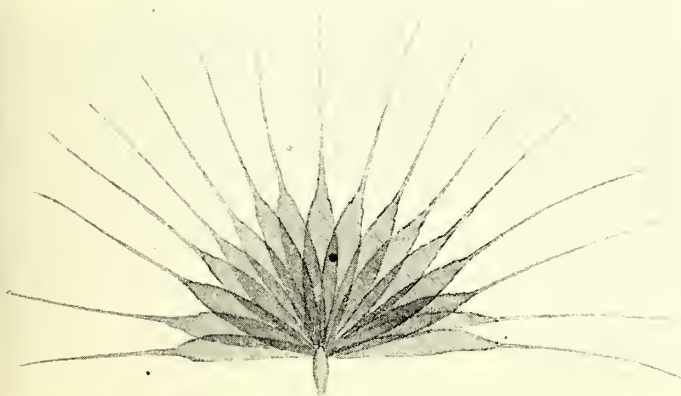
B.



B.



C.



C.

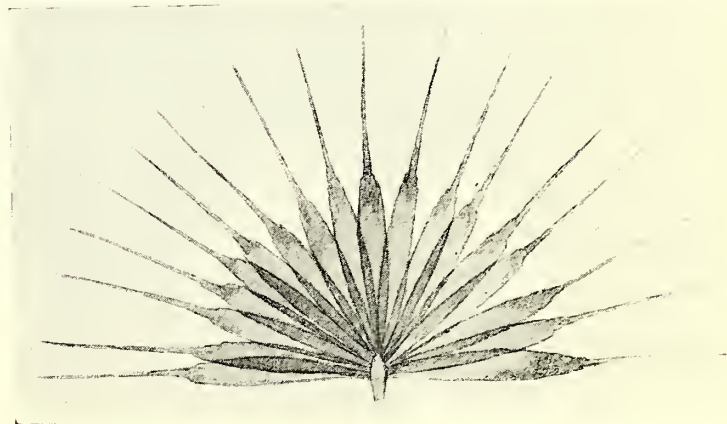


Fig. 1.—The larva of *rossi*. A.—General view ; B.—Frontal hairs magnified ; C.—A palmar hair magnified.
Fig. 2.—The larva of *stephensi*. A.—General view ; B.—Frontal hairs ; C.—A palmar hair.

Nyssomyzomyia rossi.

Head clothed chiefly with dark brown and white upright forked scales of the usual broadly expanding type and with hairs. The dark-coloured scales cover the nape and lateral areas, the white ones are inserted anteriorly and at the top. On the vertex there are a few narrowly elliptical and oblanceolate white scales, and from this area a bifid frontal tuft of white hairs and linear scales projects forward over the clypeus.

Thorax usually light fawn. The dorsum clothed chiefly with very narrow, curved, sharp-pointed, tapering scales, of a typical *Myzomyia*-like character. On the anterior promontory on each side of the mid-line a small bunch of broader sharp-pointed curved scales projects over the neck; and at the junction of the anterior with the middle third of the dorsum on each side a few broad, flat, blunt-ended *Nyssorhynchus*-like scales can usually be made out. Just beneath the lateral corners of the anterior promontory (in front of the prothoracic lobes), there is on each side a small bunch of short broadly expanding obsaggitate and oblanceolate scales. The dorsum carries a number of long hairs as well as the scales, and the scales and hairs are arranged so as to show a median, and two chief lateral longitudinal bare areas. *Prothoracic lobes* with long, bristles but without scales. *Scutellum* with bristles and a very few narrow curved scales like those on the dorsum.

Abdomen brown. Densely covered with yellowish brown hairs. The last segment of the abdomen and the genital processes carry in addition to the hairs a number of rather long blunt-ended scales. Sometimes these scales can be made out only on the genital processes, but usually they are easily seen on the last segment as well. Often they are more numerous in the male than in the female. They are present chiefly on the dorsal surface.

Wings light coloured with dark spots. The costa has seven black-scaled areas, three of which at the beginning of the vein are very small, and may be more or less joined together. The first longitudinal vein has a small spot near its beginning, and four others beneath the four outer costal spots. The spot beneath the middle costal spot is small and with the long spots on the costal and sub-costal veins a characteristic T-shaped marking is produced. The second long vein has, as a rule, two small black spots (sometimes only one) near its origin, and there are two spots on each branch. The third long vein

Nyssomyzomyia rossi.

is white-scaled, except for two small black spots near its origin and one at its termination. The fourth vein has a black spot about its middle and a longer one just before it bifurcates; there are two spots on each branch. The fifth has one spot on its stem, three on its anterior branch and one on its posterior branch. The sixth has only two black spots. The wing fringe is light scaled at the termination of all the long veins. The usual positions of the transverse veins are shown in the coloured plate. *Halteres* with light stem and brown knob.

Legs light brown, not speckled. In all the legs the distal ends of the femora, tibiae and all the tarsal segments, except the last, are tipped with narrow white bands. The bands on the tarsal segments extend over the joint to the apex of the next segment. The bands on the tarsi of the hind legs are narrower than those on the fore and mid legs.

In the *male*, variations in the wing markings are common and the outermost white palp band is usually divided into two by a narrow black-scaled band. The dorsal surface of the last abdominal segment and of the genital processes is thickly clothed with short blunt-ended white scales, a character that is usually much more conspicuous than in the female.

Characters of the eggs and larvæ (see plates). The eggs have a very broad deck surface and a broad fringe passing all round the edge of that surface. The larval frontal hairs are simple and unbranched. Palmate hairs are not present on the thorax. The terminal filament of each leaflet is very long. The pattern on the dorsal surface of the head is characteristic and constant.

Localities. Apparently this species occurs almost everywhere in the plains of India. In the hills it has been found at a height of 5,000 feet, but it is not present in hill stations like Murree, Simla and Darjeeling, which are about 7,000 to 9,000 feet. Outside India it occurs in Ceylon, Java, the Straits Settlement, Sumatra, the East Indies generally, the Phillipine Islands and Siam (Theobald, Vol. V.) A very long list of places in India where the species has been found could be given, but in the case of a species so ubiquitous, such a list is unnecessary.

Habits.—*Rossi* is essentially a "domestic" species, not as a rule found far from houses. It breeds chiefly in rain-formed pools,

Nyssomyzomyia ludlowi.

and in Bengal and the South of India in rice fields. Its larvæ have been found in water heavily contaminated with sewage. On the sea-coast near Madras its larvæ were found in very salt water. Similar observations have been made in Bombay (Bentley), the Philippine Islands (Banks), and Java (Vogel). In the Punjab the species has a very definite seasonal prevalence (from July until the end of November), but in the South of India it is common throughout the year. The adults are usually exceedingly abundant in houses and they are commonly found also in railway carriages and almost every kind of road conveyance. They have been caught on ships ten miles from the coast (see Brunetti, Catalogue of Indian Culicidæ).

It is very curious that, despite the omnipresence and abundance of this species in India, it has not yet been found infected with the sporozoite stage of the malaria parasite in Nature, and that there is much evidence tending to prove that it does not usually play a rôle in the spread of the disease in this country.

Remarks.—The reasons for placing this species in a separate genus *Nyssomyzomyia* have been given in Part I, Chapter III. It is possible that several other species now usually placed in the genus *Myzomyia* would be correctly placed in this new genus. The variations that occur in *rossi* are, as a rule, slight and of small importance. The small spots at the base of the costa may be joined together and on the first longitudinal vein under the large middle costal spot (the T-spot) there may be an additional tiny spot. There may be a tendency to mottling of the femora and tibiæ. The relative positions of the transverse veins may vary greatly.

NYSSOMYZOMYIA LUDLOWI, Theobald.

Synonym : *Myzomyia ludlowi*, Theobald.

References :—Theobald Monog. culicid., Vol. III, page 42, Vol. V, page 23.

(Figure in the Text).

Among a number of specimens of *rossi* sent to one of us from the Indian Museum collection were some specimens from the Andaman Islands which differed from the types of *rossi* in having very speckled legs. In our notes we placed these specimens as *rossi* variety *andamanensis*. In 1910 Captain Christophers sent some quite similar

Nyssomyzomyia ludlowi.

specimens from Burma and drew our attention to their resemblance to *ludlowii* from the Phillipine Islands, Singapore and the Malay States. Careful examination has shown no essential difference between our specimens from the Andamans and Burma and the detailed description of *ludlowii* given by Mr. Theobald. We, therefore, describe our specimens under that name, noting only that as our specimens carry scales (especially marked in the male insects) on the last abdominal segment and the genital processes and in this and other details of scale structure agree entirely with *rossi*, we must place them in the genus *Nyssomyzomyia*, not in the genus *Myzomyia*.

Palpi shorter than the palpi of *rossi*; with three white bands as in that species. The outermost band is narrower than in *rossi*, because the last segment of the palp is shorter than in that species (see figure). *Antennæ* brown, with whitish hairs. *Proboscis* dark brown, with a yellow tip.

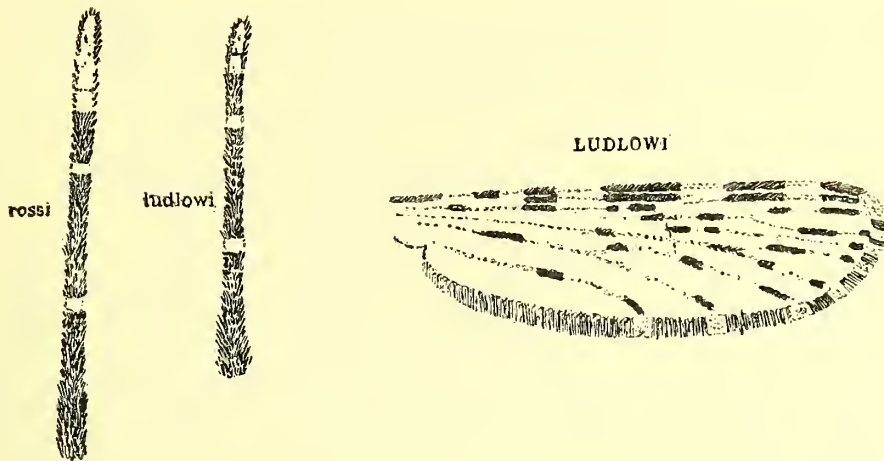
Head with very dark brown upright forked scales at the back and sides, white ones at the top in front. On the vertex there are a number of narrow, curved, sharp-pointed and blunt-ended white scales, and from this area a prominent tuft of long white hairs and linear scales projects forward.

Thorax with dark and light longitudinal areas on the dorsum. From the anterior promontory a bunch of sharp-pointed curved rather long white scales projects over the neck. The remainder of the dorsum clothed chiefly with very narrow curved sharp-pointed tapering white scales as in *rossi*. The scales are arranged more or less in longitudinal rows. When the head is removed it can be seen that beneath the anterior promontory there are some broadly expanding blunt-ended scales. *Prothoracic lobes* with long bristles, but no scales. *Scutellum* with hairs and a number of very narrow, curved, tapering scales like those on the dorsum.

Abdomen clothed almost entirely with long golden-brown hairs, but the last segment and genitalia carry also some rather long white blunt-ended scales. In the male insect the whole of the dorsal surface of the last segment is thickly clothed with these scales.

Wings very much as in *rossi*, but always with a tiny additional spot on the first longitudinal vein beneath the middle large T-shaped costal black area as shown in the figure below :

Nyssomyzomyia ludlowi.



Palp of *rossi* and *ludlowi*; wing of *ludlowi*.

Halteres with pale stem and dark knob.

Legs markedly speckled with white scales. None of the tarsal segments white in its whole length. In the fore legs the femora are only very slightly speckled; the tibiae and first tarsal segments are much speckled and at the joints between the first and second, second and third, and third and fourth tarsal segments there are broad white bands. The bands extend equally on each side of the joint. In the mid legs the femora, tibiae and first tarsal segments are speckled and at the joints there are bands similar to those on the fore legs. In the hind legs the femora, tibiae and first tarsal segments are much speckled, and there are bands at all the tarsal joints.

In the *male* insect the palpi have four (sometimes five) distinct broad white bands. The antennae are very thickly clothed with golden yellow long hairs.

Localities.—The Andaman Islands. Burma. Bengal (Fraserganj, 24-Perghs., Sunderbuns 13-11-09. Collected by J. T. Jenkins).

Remarks.—Miss Ludlow has described under the title *indefnata* some specimens that are intermediate between *rossi* and *ludlowi*. Such intermediate forms are commonly found during the examination of a large collection of *rossi* from different localities. Probably they indicate that *ludlowii* is only a local form or geographical sub-species of *rossi*. In the localities where it prevails, however, this sub-species has become constant and its markings are sufficiently different from

Nyssomyzomyia punctulata.

those of a typical *rossi* to prevent any confusion. The larval characters and the habits of this mosquito have not been described.

NYSSOMYZOMYIA PUNCTULATA, James and Liston.

(Figure facing Text.)

The following is a new description of this much spotted species.

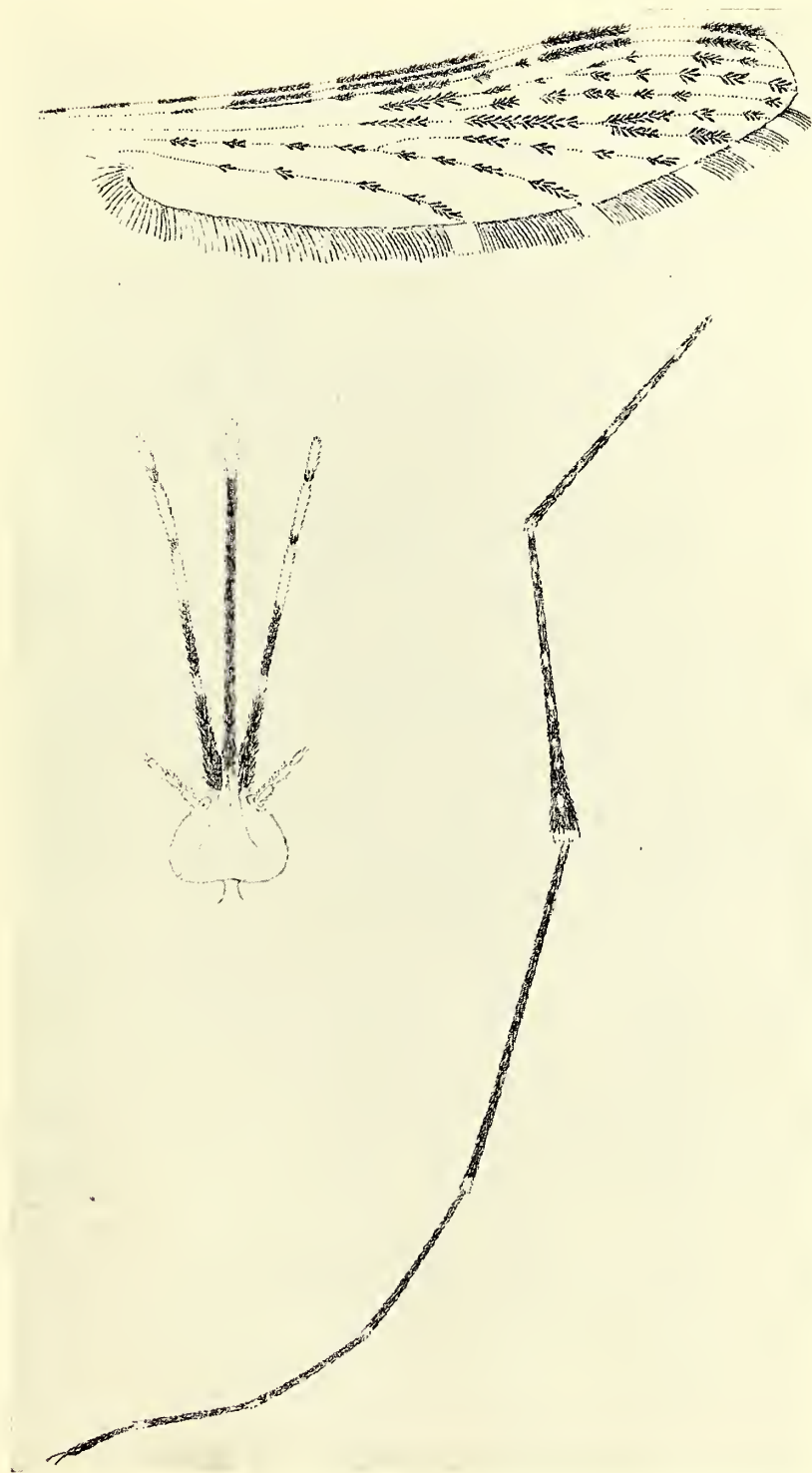
Palpi with four white bands. The outermost band includes the tip and is narrow; the two next bands are broad and of equal breadth; the fourth band is very narrow. In addition to the definite bands the palpi are speckled with white scales on the basal segment and between the fourth and third white bands. *Proboscis* yellowish white in its outer half, but with a narrow black band near the tip. *Antennæ* with some white scales on a few of the basal segments, with white hairs at the joints.

Head with the usual scale characters and with a frontal tuft of white hairs and linear scales.

Thorax chiefly clothed with hairs and *Myzomyia*-like very narrow scales, but beneath each angle of the anterior promontory there is a bunch of broadly expanding scales and from the border of the anterior promontory in the mid line a bunch of long, narrow, curved scales projects over the neck. *Prothoracic lobes* with one or two scales, but without a bunch of scales. *Scutellum* with hairs.

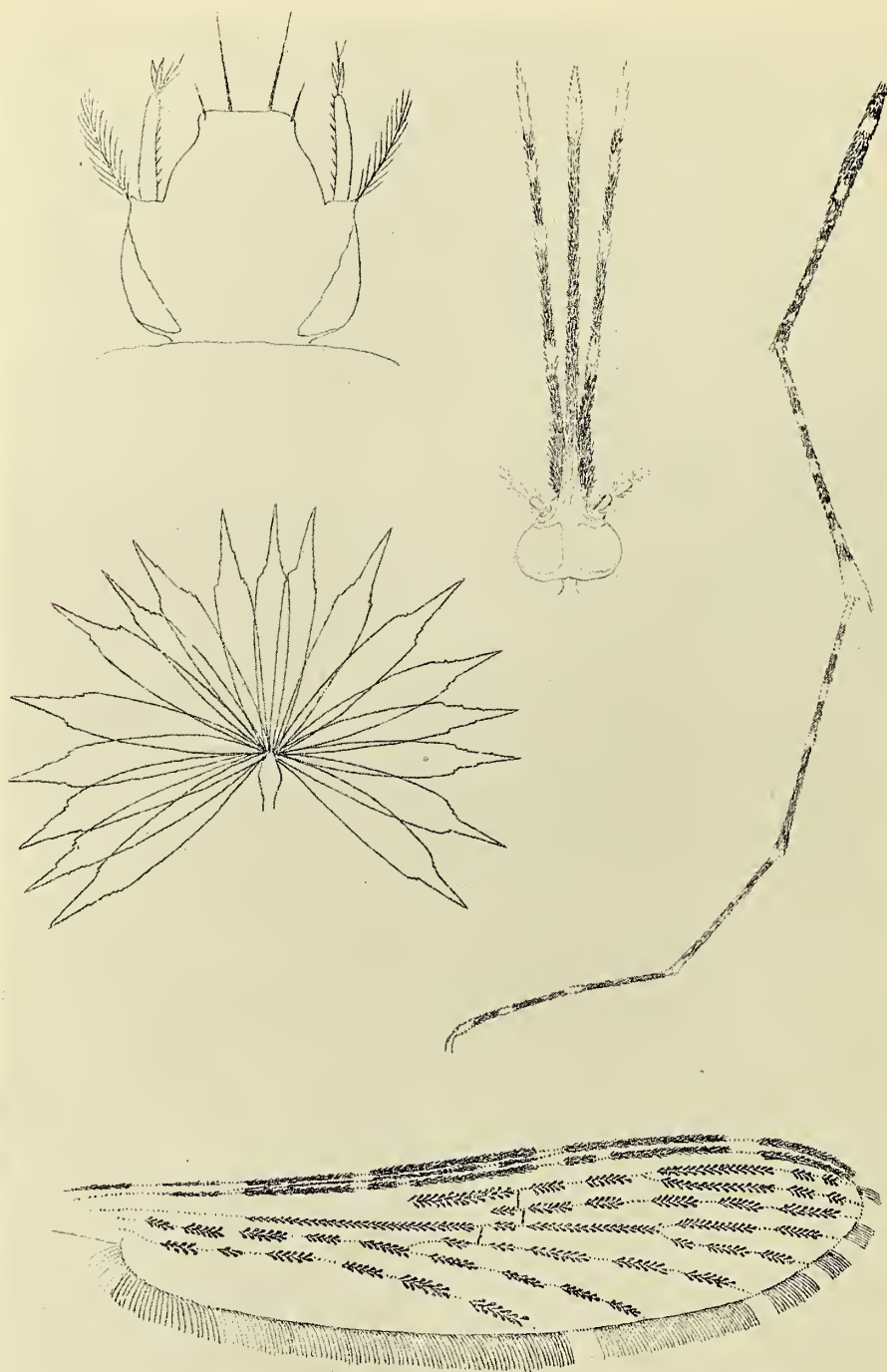
Abdomen, clothed chiefly with hairs, but the genital processes and sometimes the eighth segment carry in addition a few scales.

Wings much spotted; the veins clothed with rather broad scales. The costa has seven dark-scaled areas separated by white-scaled areas increasing in size from base to apex. Apex of wing white-scaled. The first longitudinal vein has black-scaled areas corresponding to the outer five costal areas, but the middle area is divided into three by two small white spots. The second long vein has three black-scaled areas on its stem and each branch has four or five small dark spots. The third vein has many very small black areas. The fourth at its inner third is chiefly light-scaled, its middle third is chiefly black-scaled, its branches have two or three dark areas on each. The fifth and sixth veins have many small alternate areas of black and white scales. The wing fringe is light-scaled at the apex and to the level



Nyssomyzomyia punctulata. (Note.—The drawing of the proboscis is not accurate; the outer half should have been shown as being white scaled.)





Neomyzomyia elegans.

Neomyzomyia elegans.

of the third long vein; the remainder is dark-scaled, except at the terminations of the long veins.

Legs.—In the fore and middle legs the femur, tibia and first tarsal segment are speckled with white spots; the 2nd to the 5th tarsal segments are not speckled. The 1st tarsal segment has a white band at its distal end, and the 2nd to the 4th segments have white bands at their proximal and distal ends. The 5th segment is black in its whole length. In the hind legs the femur, tibia and 1st tarsal segment are speckled. The distal ends of the femur and tibia are tipped with white and the 1st to the 4th tarsal segments have white bands at their distal ends, but no white bands at their proximal ends. The 5th segment is black in its whole length.

Localities.—Karwar (Bombay Presidency). Parel (Bombay). Delhi (Punjab; Two specimens collected by Colonel J. R. Adie in 1910). Bhandara (The Central Provinces; Specimens collected by Major W. H. Kenrick in 1910).

Remarks.—So far as we are aware, this is the only anopheline in which the proboscis is black scaled on its inner half and white-scaled on its outer half: the marking is very characteristic and enables the species to be recognised at once.

Genus NEOMYZOMYIA, Theobald (1910).

(For definition of generic characters see page 44).

NEOMYZOMYIA ELEGANS, James.

Reference:—Theobald. Vol. V, page 30.

(Figure facing text).

This mosquito, which was described in the first edition of this book as a variety of *leucosphyrus* (Dönitz), is now held to be a separate species and the type of a new genus. We have not seen a specimen of the species for some years and therefore reproduce our original description with some additions from the more recent description by Mr. Theobald.

Palpi with four white bands, the outermost of which includes the tip and is slightly broader than the others. *Proboscis* black with light tip. *Antennæ* deep brown with brown hairs, the second segment longer and larger than the others and with a few scales.

Head with broad upright forked scales which form dense tufts at the postero-lateral angles. The scales at the back of the head and

Neomyzomyia elegans.

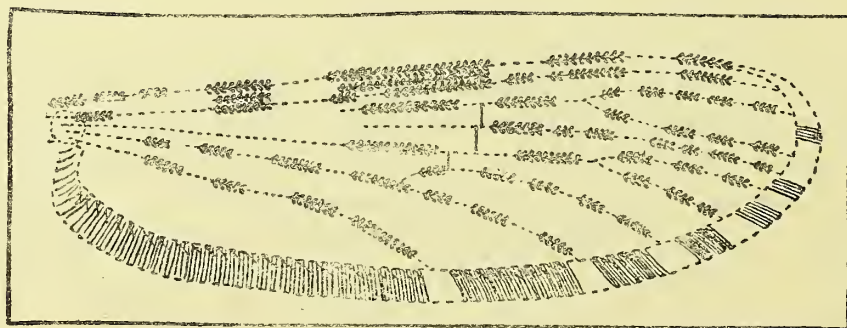
those of the tufts are black, the scales in front are white. On the vertex there are some narrow blunt-ended white scales and a tuft of long twisted linear scales and hairs projects over the clypeus.

Thorax brown to grey ; with dark longitudinal lines and two dark-eye-like spots on the dorsum. From the anterior promontory a bunch of curved, sharp-pointed, tapering scales projects over the neck. The remainder of the dorsum is chiefly clothed with golden curved hairs. *Prothoracic lobes* with a dense tuft of black outstanding scales. *Scutellum* with hair-like curved scales and long bristles. *Halteres* with the knobs clothed with creamy white scales.

Abdomen deep brown, with dark brown hairs on the first seven segments ; the eighth segment with small golden-yellow scales.

Wings with *Myzorhynchus*-like scales forming numerous spots. The costa shows four large black-scaled areas and three (sometimes only two) small ones ; the first longitudinal vein shows seven dark-scaled areas of different sizes arranged as shown in the diagram ; the main stem of the second longitudinal vein has three black-scaled areas, the anterior branch has three spots and the posterior three ; the third longitudinal vein has seven (sometimes only six) small black areas ; the fourth longitudinal vein has three large black areas on its main stem and generally three on each of its branches ; the fifth longitudinal vein has four dark spots on its main stem and one at its bifurcation, its anterior branch has five dark areas and its posterior four ; the sixth longitudinal vein has four or five (sometimes six) dark areas.

As will be seen from the accompanying drawing of the wing of another specimen, the number of dark and light-scaled areas on some



of the veins is not constant, and two or three of the small spots may sometimes be joined together so as to form one long dark-scaled area.

Neocellia indica.

The wing fringe is interrupted by a light-scaled area at the termination of each of the longitudinal veins.

The legs are speckled with white scales on a brown ground ; in the fore legs the fifth tarsal segment has a few white scales at its tip, and there are apical white scales which extend over the joint so as to form a band to each of the other tarsal segments. The first tarsal segment is speckled with white scales in addition to the apical banding, and the tibia and femur are also speckled. The markings of the mid legs are the same as those of the fore legs. In the hind legs the femora and tibiae are speckled with white scales. *At the lower end of the tibia and the upper end of the first tarsal segment there are broad white bands, the two together forming a very broad and characteristic band at this joint ;* at the other tarsal joints also there are white bands, and the tip of the fifth tarsal segment has a few white scales. None of the tarsal segments is wholly white.

Characters of the larva.—The median and external frontal hairs are simple and unbranched. There are no palmate hairs on the thorax. The filaments of the palmate hairs are rather short (see figure).

Localities.—Karwar in the Bombay Presidency. The Andaman Islands. ? The Bengal Duars.

Genus NEOCELLIA, Theobald.

(For definition of generic characters see page 44.)

NEOCELLIA INDICA, Theobald.

Reference : Theobald, Vol. IV, page 111.

(Figure in Text.)

This well marked species serves as the type of the genus *Neocellia*. Our description has been drawn up from specimens collected by Captain Christophers in the lower Punjab hills.

Palpi black-scaled and with three white bands the outermost of which does not include the tip, so that the tips of the palpi are black. The two outer bands are of about equal breadth, the third is narrower (see figure). *Proboscis* black with light tip. *Antennae* with whitish hairs.

Head with broadly expanding upright forked scales which are black at the back and sides, white in front. On the vertex a consider-

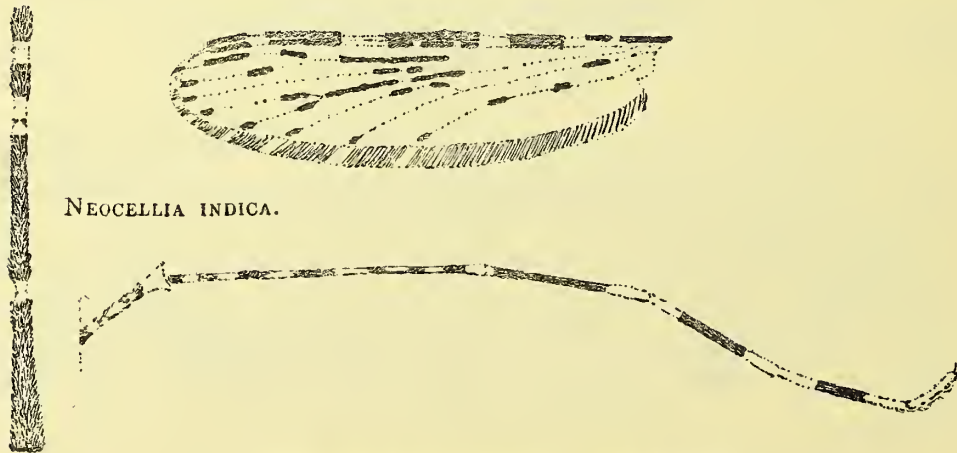
Neocellia indica.

able number of creamy white oblongate scales and a small tuft of white hairs and linear scales projecting forward.

Thorax with frosty sheen; the dorsum clothed chiefly with broad, short, creamy white scales, some sharp-pointed and slightly curved, but the majority blunt-ended. From the anterior promontory a bunch of long, sharp-pointed, tapering, curved, white scales projects over the neck. On the under surface of the anterior promontory on each side there is a small bunch of broadly expanding round-ended scales.* (*Note.*—At a superficial examination from the dorsal aspect it might be thought that these scales are a cocade projecting from the prothoracic lobes. They are not attached to those bodies.) *Prothoracic lobes* with black bristles, but without scales. *Scutellum* with its middle portion rather larger and more projecting than is usual in other anophelines; clothed scantily with scales like those on the dorsum. *Halteres* with the stems clothed with small white scales; knobs black.

Abdomen deep brown to black, with frosty sheen. The dorsal surface of every segment thickly clothed with creamy-white, rather short, quite broad, blunt and round-ended scales and with whitish hairs. The scales are irregularly disposed and although some of them project from the sides of the segments, they do not form tufts of any kind. The ventral surface is almost entirely without scales, but a few may be present on the last two segments.

Wings with rather broad scales. The costa has six black-scaled areas, two of which, at the base of the wing, are small. The first longi-



NEOCELLIA INDICA.

Palp, wing, and tarsal segments of hindleg of *indica*.

* See also the descriptions of *rossi*, *ludlowi*, *punctulata*, &c.

Neocellia willmori.

tudinal vein has four black areas corresponding to the four outer areas on the costa, but the large area in the middle of the wing is divided into three by two small white spots. The second longitudinal has two black areas on each branch and its stem is almost wholly black-scaled. The third has two tiny black spots at its beginning and one at its termination. The fourth has two long black areas on its stem and two small ones on each branch. The fifth has a small black area near its origin, three spots on the anterior branch and one on the posterior. The sixth has three spots. The wing fringe is white opposite all the long veins. The transverse veins are usually arranged in steps, the lowest being nearest the base of the wing.

Legs with all the femora, tibiae and first tarsal segments brilliantly spotted with white. In the forelegs the distal ends of the tibia and first and second tarsal segments are tipped with white. In the mid legs the distal ends of the femur, tibia and first tarsal segment are tipped with white. In the hind legs the distal ends of the femur, tibia and first tarsal segment are tipped with white and the distal end of the second tarsal segment has a broad white band continuous over the joint with a broad band on the proximal end of the third segment. The 3rd and fourth segments have broad bands at both ends and the fifth segment is white in its whole length. (See figure).

Localities.—Dehra Dun, Pathankot, and other places at the foot of the Himalayas.

Remarks.—Mr. Theobald notes some of the differences between this species and *Cellia pulcherrima*. It bears no resemblance to that species, but is very like *willmori*. The black-tipped palpi and the differences in wing-markings must be relied on for its separation from that species.

NEOCELLIA WILLMORI, James.

Synonyms : *Nyssorhynchus willmori*, Theobald.
Neocellia dudgeonii, Theobald (1909).

(Figure in Text.)

Our original description of this anopheline, although quite correct so far as it went, was incomplete. We therefore publish the following new description.

Neocellia willmori.

Palpi black-scaled and with three white bands the outermost of which includes the tip. The two outer bands are broad and of equal breadth, the third is narrow. The palpi are not speckled. *Proboscis* black, with light tip. *Antennæ* with light brown and whitish hairs. The first two or three segments carry a few white scales.

Head chiefly clothed with upright forked scales which are black at the back and sides of the head and white at the top in front. The black scales form an outstanding bunch at each postero-lateral angle of the head. On the vertex anteriorly there are a number of narrowly elliptical blunt-ended white scales and a bifid tuft of long white linear scales and hairs projects forwards.

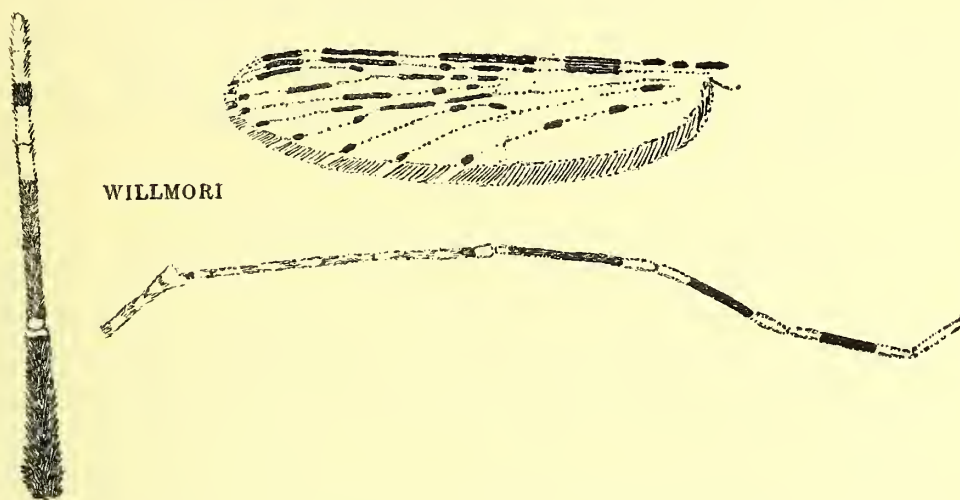
Thorax dark greyish-brown. The dorsum chiefly clothed with short, broad, creamy-white scales, some sharp-pointed, some blunt-ended. The scales are grouped roughly in longitudinal rows with bare spaces between the rows. From the anterior promontory on each side of the midline a bunch of much longer, narrower, curved tapering, sharp-pointed, white scales hangs over the neck. *Prothoracic lobes* with dark brown hairs and occasionally with one or two small scales, but never with a tuft of scales. *Scutellum* with long bristles and a number of scales like those on the dorsum. *Halteres* with whitish stem and dark knob.

Abdomen with the dorsal surface of every segment clothed with short, broad, blunt and round-ended white scales and long hairs. The scales are irregularly disposed and do not form tufts of any kind. The ventral surface of the first six segments is entirely devoid of scales, but on the ventral surface of the last two segments there are a number of scattered scales.

Wings with the veins clothed with rather broad scales, forming black and white spots. The costa has four large and three small black areas, the latter being near the base of the wing. The first longitudinal has four black areas corresponding to the outer four on the costa, but the area corresponding to the largest (middle) costal marking is divided into three by two small white spots. The second longitudinal has three spots on its stem and two on each branch. The black areas on the third vein are variable. Usually there are two small spots at its beginning and one at its termination, but there may be only one spot at the beginning and one at the end, and sometimes there is an additional rather long black-scaled about the middle as shown in the

Neocellia willmori.

drawing below. The fourth has two rather long dark-scaled areas on its stem and two small ones on each branch. The fifth has a black



Palp, wing and hind leg of *willmori*.

spot at its beginning, three (sometimes only two) spots on the anterior branch and one at the posterior. The sixth has three small spots. The wing fringe is light-scaled at the ends of all the long veins.

Legs dark brown, thickly speckled with white spots. In the fore and mid legs the femora, tibiae and first tarsal segments are speckled and their distal ends as well as the distal end of the second tarsal segment are tipped with white scales. The distal ends of the third, fourth, and fifth segments are not, as a rule, tipped with white, but sometimes the distal end of the second has a few white scales. In the hind legs the markings on the femora, tibiae and first tarsal segment are similar to those on the other legs, but the distal end of the second tarsal segment has a broad white band continuous over the joint with a broad band on the proximal end of the third segment; the third and fourth segments have broad basal and apical bands, and the fifth segment is white in its whole length. (See figure above.)

Localities.—Kashmir (collected by Lt. Willmore, I.M.S., at a height of 4,800 feet). Pathankot and other places at the foot of the Punjab hills (Captain Christophers, I.M.S.). Murree (Major F. Smith, R.A.M.C.). Almorah (Lt.-Col. Hehir, I.M.S.). Drosh, Chitral, Hindu Kush Mountains, 4,700 feet (Indian Museum Collection). Kangra Valley (A. G. Dudgeon).

A New Variety.

Habits.—Its larvæ have been found in clear pools and in streams. A description of them has not been published.

Remarks.—Mr. Theobald's *Neocellia dudgeonii* is almost certainly this species. He informed us that he had not seen a specimen of *willmori* at the time the description of *dudgeonii* was drawn up. Type examples of *willmori* are in the Indian Museum, Calcutta, and the Central Malaria Bureau, Kasauli.

NEOCELLIA WILLMORI variety MACULOSA (*var. nov.*)

This very distinct variety of *willmori* is abundant in places at the foot of the Himalayas. It differs from the type specimens chiefly as regards the markings of the palpi and some of the tarsal segments. The palpi have two broad bands and a narrow one as in the type, but between the two proximal bands there are in addition several marked patches of white scales. The following are the usual markings on the legs. In the fore legs the femora, tibiæ, and first tarsal segments are much speckled with white scales, and there is usually a patch of speckling on the second tarsal segment. The distal ends of the femora, tibiæ, and all the tarsal segments, except the fourth and fifth, are tipped with white. In the mid legs the speckling of the second tarsal segment is marked, but the white tip to the third segment is hardly perceptible. In the hind legs the second tarsal segment is also speckled, but in other respects the markings resemble the type. In all the legs, therefore, the chief difference from the type species is the speckling of the second tarsal segment. The markings on the wings are not sufficiently different from the type to need separate description. *Localities.*—Pathankot and other places at the foot of the Himalayas (S. R. Christophers, E. L. Perry). Kurseong (Dr. Annandale, specimen in the Indian Museum Collection).

NEOCELLIA DUDGEONII (Theobald).

Reference :—Theobald, Vol. IV, page 113.

We are of opinion that the specimens from the Kangra Valley described under the above name by Mr. Theobald are specimens of *willmori*, James. It is, therefore, not necessary to reproduce Mr. Theobald's description, which applies in every respect to *willmori*.

Neocellia stephensi.

NEOCELLIA STEPHENSI (Liston).

Synonyms: *Nyssorhynchus stephensi*, Theobald.

Anopheles metaboles, Theobald.

Neocellia intermedia, Rothwell.

References:—Theobald, Vol. III, page 90 ; Vol. V, page 56 ; Liston, Ind. Med. Gazette, December 1901.

(Coloured plate and plates facing the Text.)

An abundant and widely distributed species in India having a superficial resemblance to *rossi* and often found along with that species. In scale characters as well as in markings, however, it differs very greatly from that species. English entomologists have frequently confused specimens of this species with *maculatus*, but it bears little or no resemblance to that mosquito and its scale structure is quite different.

A medium sized anopheline generally light to dark brown in colour.

Palpi rather loosely scaled with dark brown scales and with three white bands and several additional white-scaled patches. The outermost band is broad and includes the tip. The next band is near to it and of equal breadth. Then there are a number of white-scaled patches, then the third (very narrow) band, and finally some more white-scaled patches at the base of the palp. In some specimens the speckling is much scantier than in others. *Proboscis* brown-scaled with a yellow tip. *Antennæ* dark brown with white hairs. The first few segments carry a few white scales.

Head with the usual type of broadly expanding upright forked scales which are very dark brown at the sides of the head and white on the nape and occiput. On the vertex anteriorly there are a number of narrow, curved, mostly sharp-pointed, white scales and a bifid tuft of white linear scales and hairs projects forward from this area.

Thorax light to dark brown. The dorsum clothed chiefly with quite broad rather short yellowish scales of a character similar to those of other species in the genus *Neocellia*, but apparently very slightly narrower. The scales are thickly arranged in longitudinal rows with a median and two lateral bare areas. From the anterior promontory on each side of the mid line a bunch of long curved tapering scales projects over the neck. *Prothoracic lobes* with hairs but without

Neocellia stephensi.

scales. *Scutellum* with scales like those on the thorax. *Halteres* with light stem and dark knob.

Abdomen dark brown. The dorsum of every segment (except sometimes the first) thickly clothed with hairs and rather long yellowish scales. The scales are arranged as in other species of the genus *Neocellia*, but they are slightly longer and narrower and not pearly white as in those species. Long golden brown hairs are also more numerous so that, on the whole, the appearance at a somewhat casual examination is rather different. The ventral surface is for the most part bare of scales, except as regards the last segment which is more or less thickly clothed on this surface. None of the scales are aggregated to form tufts and the species must be regarded as a fairly typical member of the genus *Neocellia*.

Wings rather like the wings of *rossi*; the scales a little narrower than in other species of the genus *Neocellia*. The costa has six black-scaled areas, two being small and near the base of the wing. The first long vein has four areas corresponding to the outer four on the costa, but the second area (middle of the vein) is only about two-thirds as long as the corresponding costal area and is divided into two unequal parts by a small white spot. The appearance of these markings on the costal, sub-costal and first longitudinal veins may be likened to a T with a full stop *after* it. It will be remembered that in *ludlowi*, the appearance is that of a T with a full stop *before* it, and that in *rossi* the appearance is that of a T without any full stop. The second long vein has sometimes a small black-scaled area near the beginning of its stem and one black area on each branch as in the coloured plate, but more usually there are two small areas on the stem and two on each branch. The third vein has usually two tiny spots near its origin and one at its termination. The fourth has two rather long black areas on its stem and two on each branch. The fifth has a small black spot at its beginning, three spots on the anterior branch and one on the posterior. The sixth has usually three, but occasionally only two black spots. The fringe has light-scaled areas at the ends of all the long veins. The transverse veins are variable in position but usually are arranged in steps, the lowest next to the base of the wing.

Legs dark brown. In the fore legs the femora, tibiæ and first tarsal segments are speckled with white scales and there are white

Neocellia stephensi.

bands at the distal ends of the tibiæ, and all the tarsal segments except the fourth and fifth. The bands are small and do not extend over the joint. In the mid legs the femora and tibiæ are much speckled and the first tarsal segment is sometimes slightly speckled, sometimes not at all speckled. In these legs there are tiny white tips to the distal ends of the femora, tibiæ, first and second tarsal segments. In the hind legs the femora, tibiæ and first tarsal segments are speckled, and there are white tips to the distal ends of the femora, tibiæ, and all the tarsal segments except the last. The fifth tarsal segment is black-scaled in its whole length.

The markings of the male insect do not differ materially from those of the female.

Characters of the larva (see figure). The frontal hairs are simple and unbranched. There are no palmate hairs on the thorax. The filaments of the leaflets are shorter than those of *rossi*.

Localities.—The Punjab (Lahore, Ferozepore, Amritsar and many other places). Bengal (Calcutta). Madras. The Central Provinces (Nagpur). The Berars (Ellichpur). Bombay (Bombay City), Karachi. The Lushai Hills, Assam. (The last locality recorded by Theobald.)

Habits.—Dr. C. A. Bentley has shown that this species is the carrier of malaria in Bombay. He reports that in that city it is essentially a domestic mosquito, living and breeding in the immediate neighbourhood of dwellings and adapting itself to many artificial conditions. Its larvæ were found chiefly in wells and cisterns, but they were also found in collections of fresh water of almost every kind, in brackish water and in water containing more salt than is contained in sea-water. In some of the wells in which they were present the water was 30 feet from the surface. Dr. Bentley found that the larvæ sometimes remained as long as 20 minutes at the bottom of a pool. If the larvæ which had hatched out in fresh water were placed in sea-water they quickly died, but larvæ hatched from eggs placed on sea-water lived and developed. In Calcutta and Madras the habits of this species are quite similar. In Madras its larvæ were found almost entirely in disused wells. In Mian Mir its larvæ were found chiefly in tins of water.

Remarks.—Some specimens bred by Dr. Bentley from larvæ collected in deep wells are considerably smaller than specimens bred

Cellia pulcherrima.

from larvæ collected from open pools in the Punjab; their legs are also less speckled and the wing markings show slight differences, which, however, are not sufficiently definite and constant to justify us in regarding the specimens as a distinct variety.

NEOCELLIA INTERMEDIA (Rothwell).

References :—Theobald, Vol. IV, page 115; Vol. V, page 73.

Mr. Theobald kindly forwarded ten specimens labelled as above to one of us in 1910. We found that all were specimens of *stephensi*. It is apparent also that in Mr. Rothwell's description of his specimens we have only a re-description of Liston's species and the opinion is confirmed by Mr. Carter's description of the male insect in Vol. V of Mr. Theobald's Monograph. That description was drawn up from 18 specimens in Lt.-Col. Adie's collection from Ferozepore, an area in which we are aware that *stephensi* is the only common *Neocellia*. It seems to us probable that Mr. Rothwell has mistaken the two patches of speckling commonly present on the palpi of *stephensi* for complete bands, and has therefore described the palpi as being 4-banded.

Genus CELLIA (Theobald).

(For description of generic characters, see page 45.)

CELLIA PULCHERRIMA (Theobald).

(Coloured plate and plates facing the text.)

A silvery grey species with lateral tufts of scales on the abdomen.

Palpi loosely scaled with dark brown and white scales, and with four white bands. The terminal band includes the tip and is broad, the others are narrow. Between the bands the palpi are speckled with white scales. *Proboscis* dark brown with light tip. *Antennæ* dark brown with silvery hairs. The first six segments also carry white scales.

Head clothed chiefly with broadly expanding upright forked scales which are brown at the sides of the head and pearly white on the nape, occiput and vertex. Along the posterior border of the eyes

Cellia pulcherrima.

superiorly is a row of flat overlapping white scales, and from the vertex a tuft of white linear scales and hairs projects forwards.

Thorax with the dorsum thickly clothed with broad silvery white oval scales arranged in three broad longitudinal rows with bare spaces between. On the anterior promontory the scales are longer, narrower, and sharp-pointed. *Prothoracic lobes* without a tuft of scales. *Scutellum* with long bristles and scales like those on the thorax. *Halteres* yellowish-brown; the knobs with a number of silvery scales.

Abdomen thickly clothed with very broad orbicular and rotundate pearly-white scales, which on the posterior borders of the segments project from the surface and overlap one another. In addition from the postero-lateral corners of each segment a prominent tuft of dark brown scales projects transversely. The ventral surface is also clothed with broad white scales like those on the dorsum, but there are no ventral tufts.

Wings with the veins clothed with large, broad scales. The costa has six black-scaled areas, two being small and at the base of the wing. The first longitudinal has four black areas corresponding to the four outer areas on the costa, but the second area is divided into three by two white spots. The stem of the second long vein is white-scaled; there are two black spots on each of its branches. The third vein has two small spots at its beginning and one at its end. The fourth is black-scaled at its bifurcation, and there are two black spots on each branch. The fifth has a small black spot at its beginning and there are three spots on the anterior branch and one on the posterior. The sixth has three black spots. The wing fringe is white-scaled opposite each long vein.

Legs covered with white and brown scales irregularly disposed. In the fore legs the femora and tibiae are white on the under surface and speckled with brown scales on the upper; the distal end of the tibia is tipped with white and every tarsal segment, except the fourth and fifth, has a broad apical band. In the mid legs the markings are similar, but near the lower end of the femora there is a broad oval white patch. In the hindlegs there is a similar patch on the femora and the last $3\frac{1}{2}$ or $3\frac{3}{4}$ tarsal segments are white in their whole length.

In the male insect the palpi have five broad, almost equal, white bands. The other markings do not differ materially from those of the female.

Myzorhynchus barbirostris.

Characters of the larvæ.—The median frontal hairs are simple, the external are branched. There are no palmate hairs on the thorax. The terminal filaments of the leaflets are long.

Localities.—Common in the Punjab (Lahore, Mian Mir, Ferozepore, Amritsar, Delhi, etc.). The N.-W. Frontier Province. The Bombay Presidency (Goa).

Habits.—Its larvæ have been found in rain-formed pools. In the Punjab this species is able to live through the winter in the adult state.

Genus MYZORHYNCHUS (Blanchard).

(For description of generic characters, see page 46.)

MYZORHYNCHUS BARBIROSTRIS (Van der Wulp).

(Coloured plate and plates facing the text.)

A large black mosquito easily recognised by its densely scaled, entirely black, unbanded palpi.

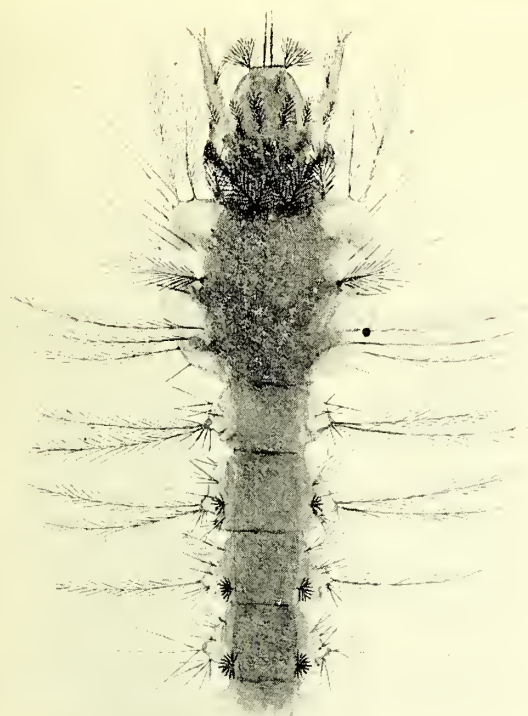
Palpi thickly clothed with broad outstanding black scales which are more densely aggregated on the proximal than on the distal segments; without any white bands. *Proboscis* clothed entirely with black scales which are rather outstanding on the basal half. *Antennæ* with black hairs at the joints.

Head clothed chiefly with very broadly expanding upright forked scales, which are black on the nape and sides, white on the occiput anteriorly. On the vertex a few white curved scales and a tuft of linear scales and hairs projecting forward.

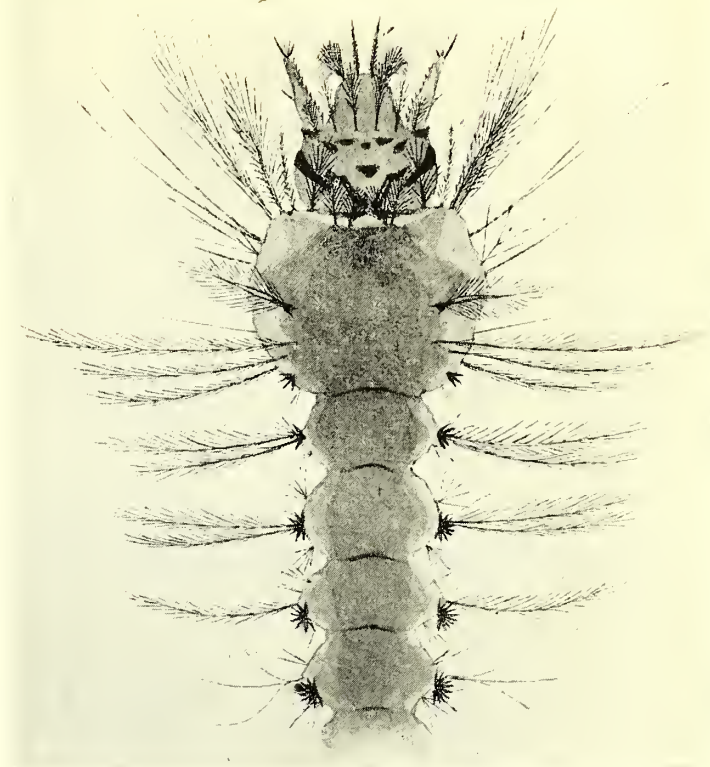
Thorax black; the dorsum clothed with white, very narrow, curved, sharp-pointed Myzomyia-like scales. *Prothoracic lobes* with a dense tuft of broad scales projecting anteriorly. *Scutellum* with bristles and a few scales like those on the dorsum.

Abdomen with the dorsal surface of segments 1 to 7 clothed with hairs only. On the 8th segment there are some scales. On the ventral surface from the apex of the seventh segment in the middle line a prominent bunch of rather long, black, true, scales projects downwards. A few small white scales are present on the ventral surface of the sixth, fifth, fourth and third segments.

FIG. 1.



A.



A.



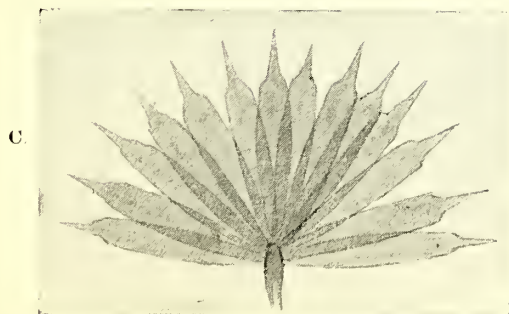
B.



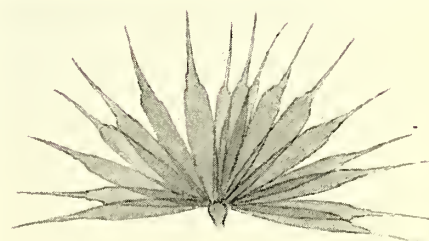
D.



B.



C.



C.

Fig. 1.—The larva of *My. barbirostris*. A.—General view; B.—The frontal hairs magnified; C.—A palmate hair magnified; D.—The branching hair on the inner side of the antenna of *My. barbirostris* larva. Fig. 2.—The larva of *N. fuliginosus*, A.—General view; B.—The frontal hairs magnified; C.—A palmate hair magnified.

Myzorhynchus barbirostris.

Wings with the veins clothed with large broad scales. The costa has a few white scales at its outer end and a patch at the junction of the outer and middle third of its course. The first long vein is chiefly black-scaled with a few white scales interspersed irregularly. There is a patch of white scales near its beginning. The second long vein is entirely black-scaled, except for a patch of white scales on its posterior branch. The third vein is black-scaled with a few white scales irregularly scattered among them. The stem of the fourth vein is entirely black-scaled, but on the anterior and posterior branches there are patches of white scales. The fifth vein is irregularly clothed with patches of black and white scales; on each branch the white scales form two distinct patches. On the sixth vein some of the scales are black, some white, the white scales form two more or less distinct spots. The wing fringe is mostly dark-scaled, but there is a light patch at the apex and another at the extremity of the posterior branch of the fifth vein.

Legs dark-brown to black; with white scales at all the joints. None of the tarsal segments is white in the whole length.

Characters of the larva (see figure). On the inner side of the antenna is a large branching hair. The median frontal hairs are usually simple, but may be forked. The external frontal hairs form a much branched cocade. The leaflets of the palmate hairs are rather short.

Localities.—The outskirts of Calcutta and many places in the plains of Bengal. The Central Provinces. Amritsar, Ferozepore, Lahore, Delhi, Atari, and other places in the Punjab. Chittagong and other places in Eastern Bengal and Assam. The Bombay Presidency. The South of India (near Trivandrum in the Travancore State).

Habits.—The larvæ of this species are usually found in shady pools with much vegetation or in tanks overgrown with weed. More than one or two larvæ are seldom found in the same pool. Adults are never abundant and are seldom present in houses.

Remarks.—The drawings of the wing scales of *Cyclolepteron mediopunctatus* and *intermedium* on pages 33 and 34 of Vol. V of Mr. Theobald's Monograph might serve excellently as drawings of the wing scales of *barbirostris*.

Myzorhynchus sinensis.

MYZORHYNCHUS SINENSIS (Wiedmann).

Synonyms : *Myzorhynchus nigerrimus*, James and Liston (not Giles).

Myzorhynchus minutus, Theobald.

Myzorhynchus vanus, Walker.

(Coloured plate under the title *nigerrimus*, and plates facing the text.)

Since the publication of the first edition of this book we have examined a large number of specimens from both India and China identified as *sinensis*, Wiedmann, *nigerrimus*, James and Liston, or *vanus*, Walker. We have been unable to detect a specific difference between any of these specimens, and we therefore consider that the correct name for all of them is *sinensis*, Wiedmann. Mr. Theobald is of the same opinion. As regards *nigerrimus*, Giles, which is supposed to differ from *nigerrimus*, James and Liston (that is from *sinensis*), by having black tipped palpi, no subsequent searcher in India has yet found a specimen with that character, and we think it must now be admitted either that Colonel Giles wrongly described the palp markings of his specimen or that the specimen was a rare variety which has not been found since. We have already described a rather common variety of *fuliginosus* with black tipped palpi (variety *nagpori*), and it is quite possible that a similar variety of *sinensis* might occur.

The following is the description of *sinensis*. It will be found that the characters of all the specimens formerly identified in India as *nigerrimus*, James and Liston, or as *vanus*, Walker, or as *minutus*, Theobald, agree with it in every detail. Mr. Theobald founded the species *minutus* upon a single specimen of our *nigerrimus* sent by Captain Christophers from Lahore, but except as regards size, which is a character of no value, it does not differ from that mosquito and the name must be sunk, along with the name *nigerrimus*, in the correct title *sinensis*.

Palpi thickly clothed with outstanding scales; with four white bands the outermost of which includes the tip. On the basal segment some whitish scales are mingled with the dark ones. *Proboscis* black with lighter tip. *Antennæ* with the basal segments carrying a few white scales.

Myzorhynchus sinensis.

Head clothed on the nape and lateral areas with broadly expanding black upright forked scales and on the occiput with white ones. From the vertex a tuft of white hairs and linear scales projects forwards.

Thorax with the dorsum clothed with yellowish hairs and very narrow Myzomyia-like scales. The scales and hairs are grouped in longitudinal rows with bare spaces between. On the anterior promontory a bunch of white narrow tapering sharp-pointed scales projects over the neck. *Prothoracic lobes* with a cocade of broad scales projecting from its anterior border. *Scutellum* with hairs and some scales like those on the dorsum. *Halteres* with light stem and dark knob.

Abdomen with the dorsal surface clothed entirely with yellowish hairs. The ventral surface almost bare, but from the apex of the seventh segment in the mid line a more or less prominent tuft of black blunt-ended scales projects vertically downwards. On the apices of a few of the other segments a few white scales may be present.

Wings with the veins clothed with scales which are longer, narrower, and more pointed than those of *barbirostris*. The costa has two chief white-scaled areas, both in the outer half of its course. The first longitudinal has three areas where white scales predominate over black ones. The first area is situated just before the origin of the second long vein, the others correspond to similar white areas on the costa. The second long vein has a few white scales mingled with the black ones on its stem and a distinct area of white scales on each branch. The third vein has usually more white scales than black ones, but there is a distinct black area at its beginning and another at its end. The stem of the fourth vein is about equally covered with light and dark scales, but it is chiefly black-scaled at the junctions of the transverse veins, at its bifurcation, and at the ends of its branches. The fifth vein has a distinct black-scaled area near its origin, and there are three rather indefinite black areas on its anterior branch and one on its posterior branch; otherwise this vein is almost entirely white-scaled. The sixth vein has two black-scaled areas. The wing fringe is white-scaled at its apex, the white-scaled area lying between the anterior branch of the second vein and the termination of the third vein.

Myzorhynchus nigerrimus.

Legs brown, very long. In the fore legs there are small white bands at the distal ends of the tarsal segments, except the fourth and fifth. In the hind legs there are small bands at all the joints. None of the tarsal segments is white in its whole length.

Characters of the larva.—The median frontal hairs are unbranched, but may be bifurcated. The external frontal hairs are much branched and form distinct cocades in front of the whorl organs. The antennæ have a large branching hair on their inner side. Palmate hairs are not present on the thorax.

Localities.—Common in Bengal (Calcutta, Jalpaiguri, etc.). The Punjab (Lahore, Ferozepore, Delhi, Amritsar). Assam [Sylhet, Ukhral (Manipur, 6,400 feet)]. The Bombay Presidency. The Madras Presidency. The Travancore State.

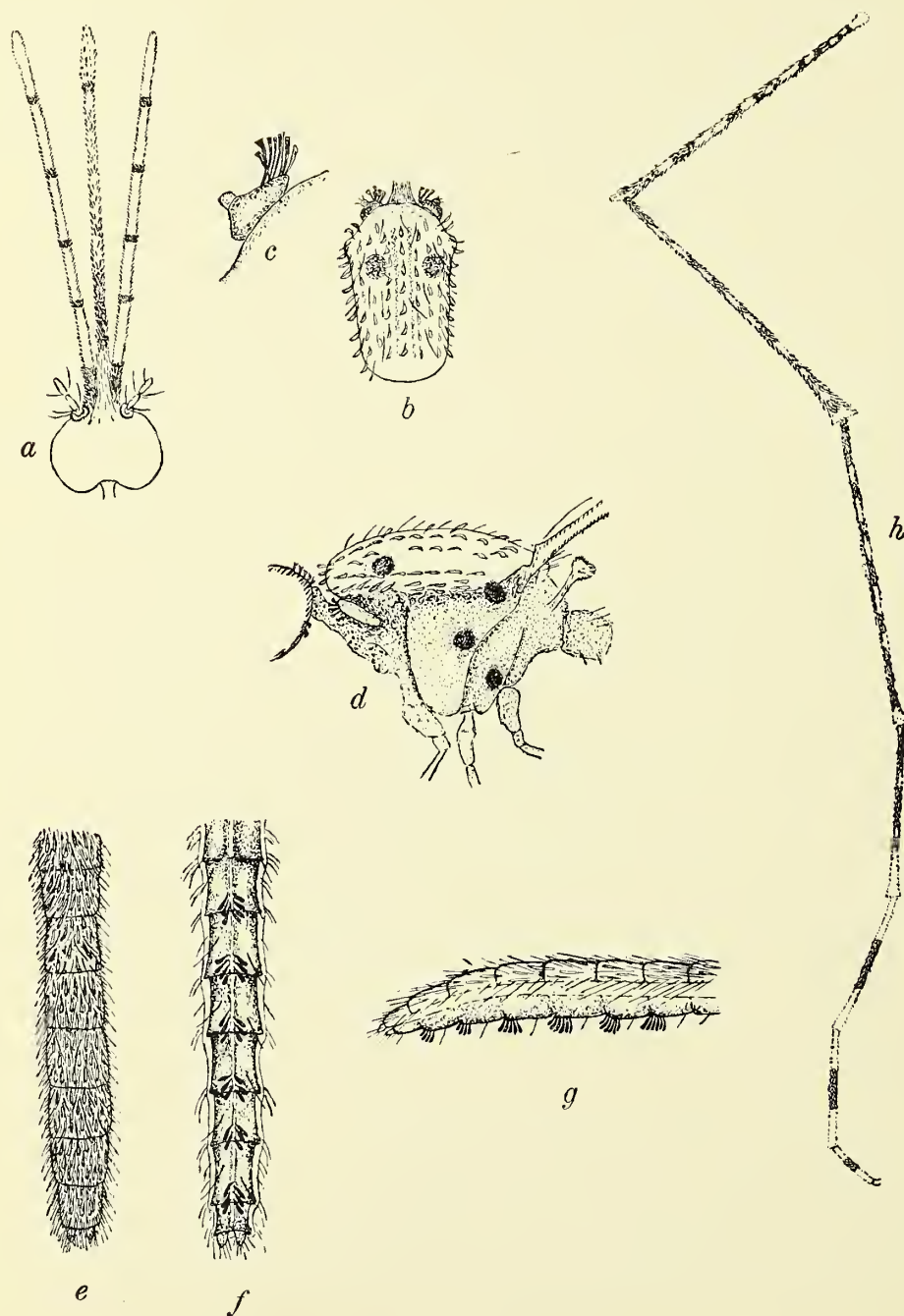
Habits.—Its larvæ are usually found in deep shady pools at some distance from houses. The adults have been caught in houses and on river steamers.

Remarks.—The members of this species, as of all others, vary greatly in size. Our largest specimen measures from the tip of the proboscis to the end of the abdomen 12 mm. Its hind legs measure 15 mm. and its wings 5 mm. We have other specimens in which the hind legs measure only 11 mm. and the wings 4 mm. The markings, however, of the different sized specimens are identical.

A specimen of *sinensis* can easily be distinguished from a specimen of *barbirostris* by the quite different character of the wing scales, but in more important scale characters the two species agree. This shows that we ought not to rely upon the shape of wing scales for generic differences.

MYZORHYNCHUS NIGERRIMUS (Giles).

Colonel Giles is apparently of opinion that his *nigerrimus* should be regarded as a specimen of *sinensis*, Wiedmann (see his Revision of the *Anophelinæ*, page 38). Mr. Theobald, however, relying upon a statement that the tips of the palpi of Col. Giles' species were black has placed it as a distinct species. If it is a distinct species it must be exceedingly rare as no observer has found a specimen during the ten years since it was described. In 1901, Mr. Theobald said that the



Christophersia halli. A, Palps from the dorsal aspect; B, Dorsum of thorax; C, Prothoracic lobe; D, Lateral view of thorax; E, Dorsum of abdomen; F, venter of abdomen; G, Lateral view of abdomen; H, hind leg.

Christophersia halli.

specimens of the species in the British Museum were bad specimens, and we therefore think it probable that the description was incorrect.

MYZORHYNCHUS MINUTUS (Theobald).

In 1903, Mr. Theobald described under this name a single specimen sent to him from Lahore by Captain Christophers. It is evidently identical with our *nigerrimus* and therefore with *sinensis*, Wiedmann.

MYZORHYNCHUS VANUS (Walker).

The Indian Museum collection contains some specimens identified under the above title by Mr. Theobald. The Superintendent of the Museum has informed us, however, that since they were determined Mr. Theobald has written that *vanus* and *sinensis* are identical.

Genus CHRISTOPHERSIA (James).

(For description of generic characters, see page 46.)

Reference :—Records of the Indian Museum, Vol. IV, No. 5, 1910.

CHRISTOPHERSIA HALLI (James).

Reference :—Paludism, No. 1. July 1910.

(Figure facing text.)

A golden brown species of medium size.

Palpi very slightly shorter than the proboscis; clothed with white, yellow, and black scales; tips yellowish white. The dorsal surface of each palp has five broad white bands separated from one another by four narrow black bands, but the ventral surface shows only three broad white bands and two broad black ones. *Proboscis* brown to yellow at the tip; clothed scantily and irregularly with black scales which, however, form a narrow black band near the tip. *Antennae* light brown to yellow, with white hairs at the joints.

Head with many upright forked scales of the usual broadly expanding type, some white, some black; and with a few creamy-white narrow curved scales on the vertex anteriorly. A tuft of white hairs projects forwards from the vertex.

Christophersia halli.

Thorax golden brown with dark eye-like spots. The dorsum clothed with rather broad short white scales and white and brown hairs. Two dark eye-like spots are present on the anterior third of the dorsum in the situation shown on the plate. Lateral surfaces of the thorax fawn coloured. On each lateral surface there are three dark eye-like spots. *Prothoracic lobes* with a tuft of scales projecting forward. *Scutellum* with hairs and a few scales like those on the thorax. *Metanotum* nude. *Halteres* with the stem and knob clothed with silvery white scales and with a patch of dark brown scales on each knob.

Wings with the veins clothed with broad scales. The costa has two or three tiny black spots at its beginning and five principal spots, the second of which is smaller than the others. The first long vein has four black-scaled areas corresponding to similar areas on the costa, but the second area is divided into two by a few white scales. In some specimens the third area is also divided into two. The second long vein has two or three tiny black-scaled areas on its stem and there are two on the anterior branch and three on the posterior branch. The third vein is white-scaled, except for a small spot at its beginning and another at its end. The fourth has three or four spots on its stem and two on each branch. The fifth has one spot on its stem and there are three on the anterior and one on the posterior branch. The sixth has three small black spots. The wing fringe is chiefly light-scaled, but there are a few dark scales in the areas between the terminations of the long veins.

Legs. The femora, tibiae and first tarsal segments of all the legs are marked with brilliant white spots and blotches. In the fore legs there is a blotch of white scales at the joints between the first and second, second and third, and third and fourth tarsal segments. In the mid legs there are very small white patches at the tarsal joints. In the hind legs the femora and tibiae have small white apical bands, the first tarsal segments have small apical bands, and the second segment has a longer apical band; the third, fourth and fifth segments have both basal and apical bands, the apical band of the fifth segment including the tip. (See plate.)

Abdomen light brown. The dorsal surface of each segment is thickly clothed with yellow rather long scales and with golden hairs. The scales are not aggregated to form tufts. The ventral surface is

Aldrichia.

dark brown in colour and bare, except that from the apices of six segments in the middle line prominent tufts of long, broad, blunt-ended, black scales project vertically downwards. These scales are inserted close to and on each side of the mid line; they cannot be seen when the dorsal surface is being examined, but the six tufts at once become prominent objects when the mosquito is turned on its side.

The male insect differs in marking very little from the female and a separate description of it is unnecessary.

Larvæ not known.

Localities. Sylhet, Assam. Specimens collected in February, June, July and December.

Remarks. Collected in 1905 by Lieut.-Col. Hall, I.M.S., after whom the species is named. The genus is named after Captain Christophers, I.M.S. Mr. Theobald has informed us that both the genus and species are new to entomological science. The specimens were contained in a collection of mosquitoes sent to one of us from the Indian Museum. They were labelled *Cellia kochii*, Dönitz. Type specimen in the Indian Museum, Calcutta.

Genus ALDRICHIA (Theobald).

(See page 42.)

It appears that since 1903, when the single specimen on which this genus was founded was described, no other specimen resembling it has been found. In Vol. V of his Monograph (1910), Mr. Theobald notes that the specimen has been destroyed.



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H.

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L.

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P.

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W.

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 ,, variety *maculosa*, **112**.

COLOURED PLATE No. 1.

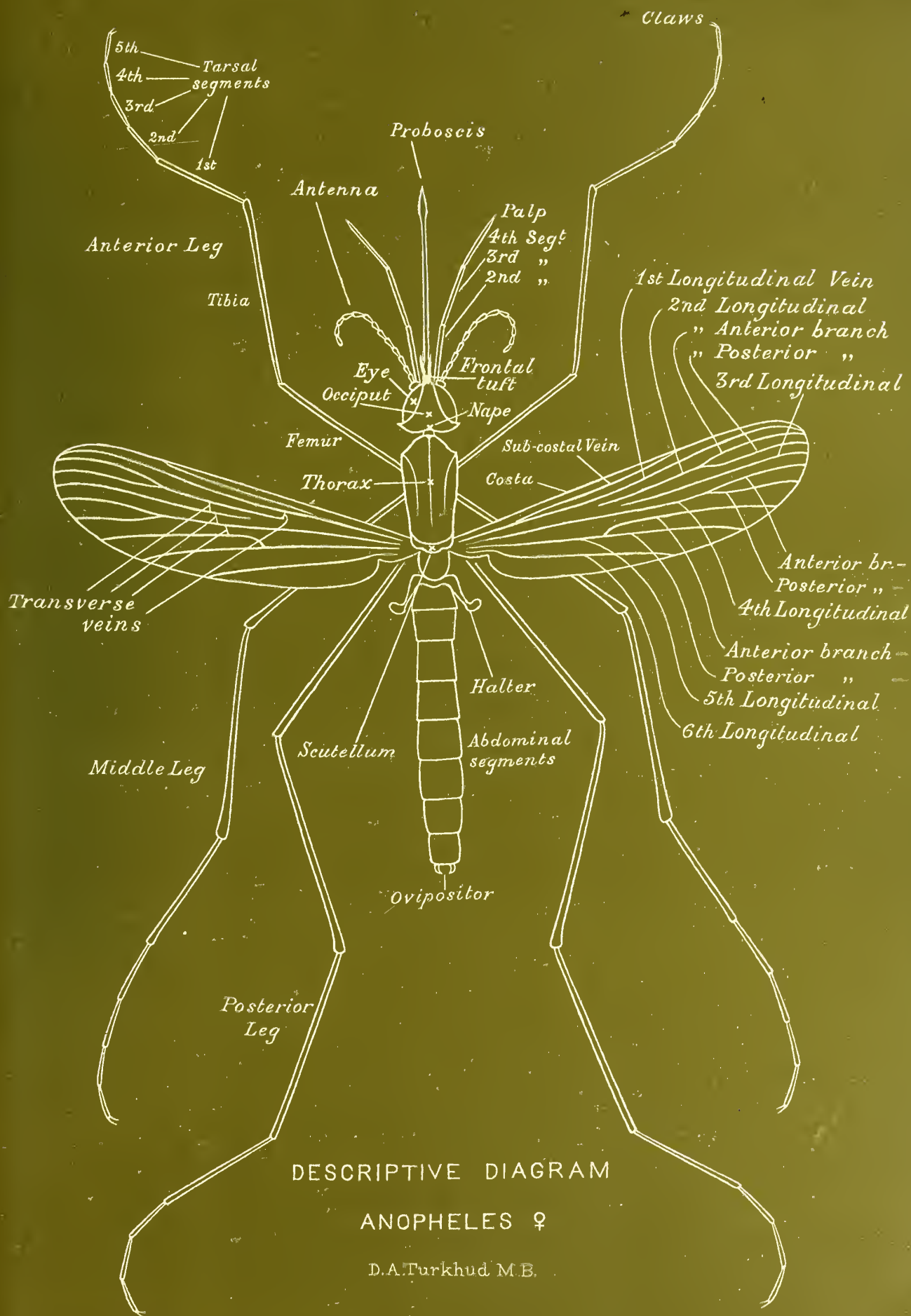
Descriptive Diagram of a Female Anopheline.

Description on page 10.

REVISED EDITION

Descriptive Diagram of a Female Anopheles.

PLATE I.



DESCRIPTIVE DIAGRAM

ANOPHELES ♀

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COLOURED PLATE No. II.

Patagiamyia lindesayi (Giles).

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ANOPHELES LINDESAYI

♀

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COLOURED PLATE No. III.

Myzomyia culicifacies (Giles).

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ANOPHELES CULICIFACIES

♀

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COLOURED PLATE No. IV.

Myzomyia listoni (Liston).

Synonym, *Myzomyia fluviatilis*.

Description on page 73.

THE HISTORY OF

THE HISTORY OF

THE HISTORY OF

THE HISTORY OF



ANOPHELES FLUVIATILIS

♀

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COLOURED PLATE No. V.

Anopheles turkhudi (Liston).

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Anopheles turkmeni (Liston).

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ANOPHELES TURKHUDI

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COLOURED PLATE No. VI.

Pyretophorus jeyporiensis (James).

Description on page 81.

ΕΥΡΩΠΑΪΚΟ ΠΑΡΛΕΜΕΝΤΟ



ANOPHELES JEYPORIENSIS

♀

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COLOURED PLATE No. VII.

Nyssorhynchus fuliginosus (Giles).

Description on page 86.

7-hydroxyflavone (100%)



ANOPHELES FULIGINOSUS

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COLOURED PLATE No. VIII.

Nyssorhynchus jamesi (Theobald).

Description on page 90.



ANOPHELES JAMESII

♀

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COLOURED PLATE No. IX.

Nyssorhynchus maculipalpis
(James and Liston).

Description on page 92.

THE

YESSOHYNCHUS DISCIPULUS
(James and John)



ANOPHELES MACULIPALPIS

♀

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COLOURED PLATE No. X.

Nyssorhynchus theobaldi (Giles).

Description on page 94.

THE

PROCEEDINGS OF THE



ANOPHELES THEOBALDI

♀

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COLOURED PLATE No. XI.

Nyssomyzomyia rossi (Giles).

Description on page 97.

GEORGE W. W. W. W.

Nyssonymia (Giles)



ANOPHELES ROSSII

♀

D.A. Turkhud M.B.



COLOURED PLATE No. XII.

Neocellia stephensi (Liston).

Description on page 113.



ANOPHELES STEPHENSI

♀

D. A. Turkhud M.B



COLOURED PLATE No. XIII.

Cellia pulcherrima (Theobald).

Description on page 116.

Central Public Library



ANOPHELES PULCHERRIMUS

♀

D.A.Turkhuđ M.B.



COLOURED PLATE No. XIV.

Myzorhynchus barbirostris
(Van der Wulp).

Description on page 118.

17. zu den 17. 17. 17.
M. 17. 17. 17. 17. 17.



ANOPHELES BARBIROSTRIS

♀

D.A.Turkhud.M.B.



COLOURED PLATE No. XV.

Myzorhynchus nigerrimus (James
and Liston ; = sinensis,
Wiedmann).

Description on page 120.



ANOPHELES NIGERIMUS

♀

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